CERAMIC ABSTRACTS and THE BULLETIN

OF THE

AMERICAN CERAMIC SOCIETY

OCTOBER 15, 1944

MONTHLY PUBLICATION DEVOTED TO THE ARTS AND SCIENCES RELATED TO THE SILICATE INDUSTRIES

MEMBERSHIP ROSTER

Ceramic Abstracts Section 147-162 CERAMIC ABSTRACTS and THE BULLETIN, Vol. 23, No. 9, SEPTEMBER 15, 1944 The Bulletin Section 163-174

MICROMAX AND OTHER L&N PYROMETERS

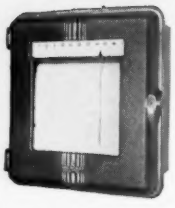


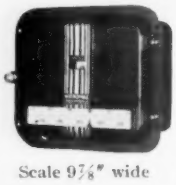
Chart 9⅞" wide

MODEL S MICROMAX has more capacity and flexibility than any other Pyrometer for the dependable operation of automatic controls, including electrically- and pneumatically-operated proportional controls for close, accurate regulation of any furnace, etc. Also operates signals if desired. Widely used to record as many as 16 temperatures of crowns, spouts, etc. on a wide, easily read chart; indicates clearly on a straight scale $9^{7}/_{8}$ inches wide, in as many as 6 colors. Standardizes itself; signals for fresh dry cells, ink and chart well in advance of need; is industry's most fully-automatic pyrometer. For use with thermocouples see Cat. N-33A; with Rayotubes (radiation thermopiles), Cat. N-33B; with Thermohms (electric resistance thermometers), Cat. N-33C.

MODEL S MICROMAX Indicator neither records nor controls; is for high-speed "fanning through" of a large number of thermocouples; used where Manual Indicator is too slow.

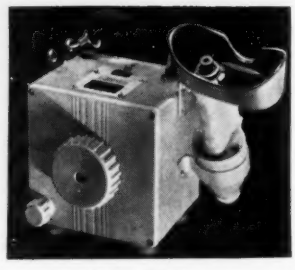
Chart diameter 10"

MODEL R MICROMAX is outstandingly dependable for operating electrically-actuated automatic controls for all types of kilns, lehrs, tanks and other ceramic and glass furnaces. Also operates signals if desired. Can be read at greater distance than any other Pyrometer. Records one or two temperatures. Used with same temperature detectors as Model S. Like every Micromax, Model R has the sturdy, reliable mechanism which has made these instruments standards of accuracy. Same catalogs as Model S above.



Scale 9⅞" wide

MODEL C MICROMAX controls and indicates; does not record. Single-point only, for outstandingly dependable operation of electrically-actuated controls or signals. Self-standardizing potentiometer circuit. Used with thermocouples or Rayotubes as detectors. Same catalogs as Model S above.

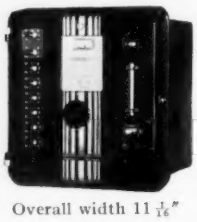


⅛ Actual Size

OPTICAL PYROMETER, potentiometer type, visually measures temperatures from 1400 to 5200° F. Operator sights telescope on hot object, balances brightness of lamp filament against brightness of field, adjusts circuit to balance galvanometer, and reads temperature directly on the instrument's scale. Catalog N-33D.

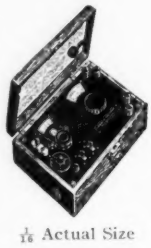
Overall width 15"

MODELS N AND NC MICROMAX are used where nothing but control is desired—no indicating, no recording. For two-position electrically-actuated controls only. MODEL N, illustrated at right, has mercury control switch. MODEL NC has either mercury control switch or open-type control contacts. Same catalogs as Model S.



Overall width 11 $\frac{1}{16}$"

MANUALLY-OPERATED INDICATORS, for thermocouples, Rayotubes or Thermohms; read directly in temperature. In portable form, Indicators are carried and used anywhere. In permanently-installed form, Indicators are used at a central location to check scattered points. Same catalogs as Model S.



⅛ Actual Size

APPARATUS FOR CHECKING thermocouple pyrometers includes potentiometers, standard thermocouples and accessories. Potentiometers, calibrated in millivolts for use with any couple, are available in portable and table models, with ranges and accuracies suitable for tests in plant and laboratory. Electric checking furnace is supplied for comparing standard and test couples. All listed in Catalog E-33A-503.

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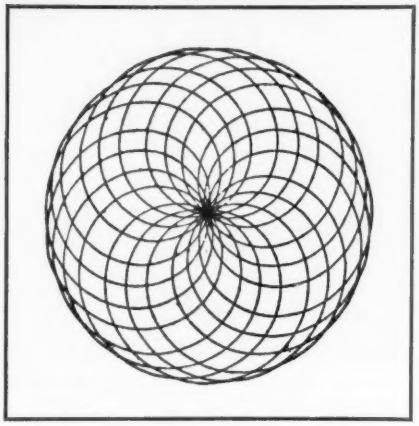
Let us show you how application of the "Lancaster" principle can improve your batch mixing. Write today. No obligation.

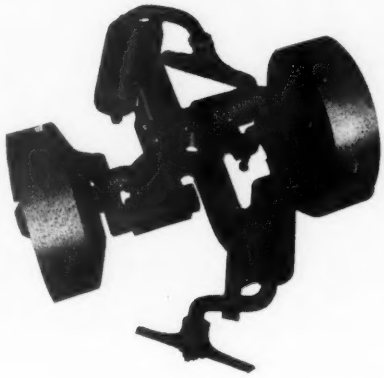
Illustration shows how material is conveyed by clockwise rotation of mixing pan and deflected by stationary side wall plow into the path of counter-clockwise rotating plows and muller which are established off-center of pan diameter.

MIXERS

"Lancaster" Mixers' Balanced Mixing-Mulling Action



The above diagram clearly illustrates the paths covered by mixing tools during one revolution of the pan.



"Lancaster" Mixers offer a selection of mixing tool equipment. Flexibility of mixing tool elements balances the action to requirements of different formulas . . . fostering scientific control.

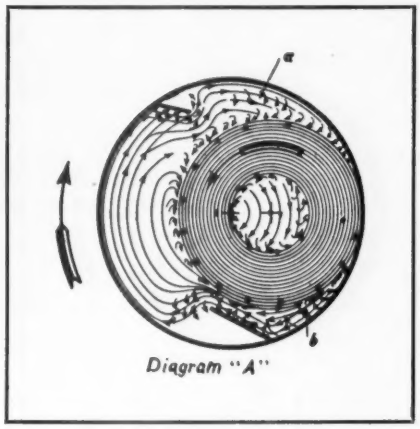
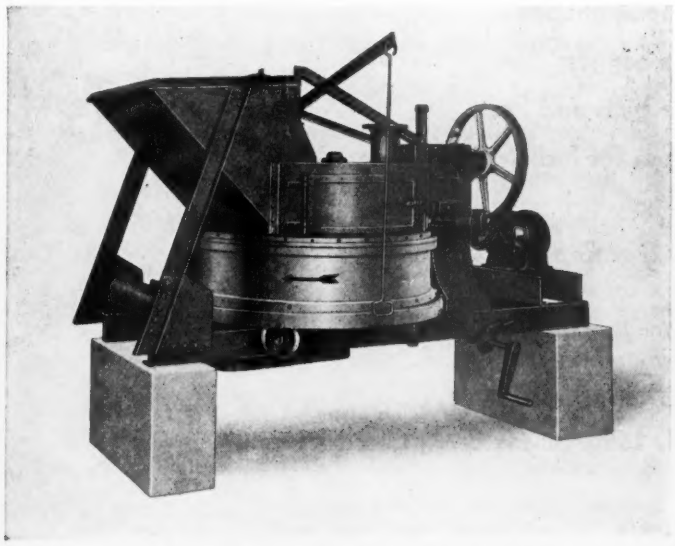


Diagram "A"

Material conveyed by the pan in clockwise direction at moderate velocity is diverted by a stationary side scraper plow into the narrow trough at "A." It is picked up by the counter-clockwise rotating mixing tool equipment, set off-center of the mixing pan and rotated around its vertical axis. Material leaving the whirlpool at "b" is picked up by a stationary bottom plow and turned around its horizontal axis, in waves, bringing bottom layers to the top. Countless crossing-over points are created by this ever-changing activity . . . turning, dividing and dispersing without "free fall."



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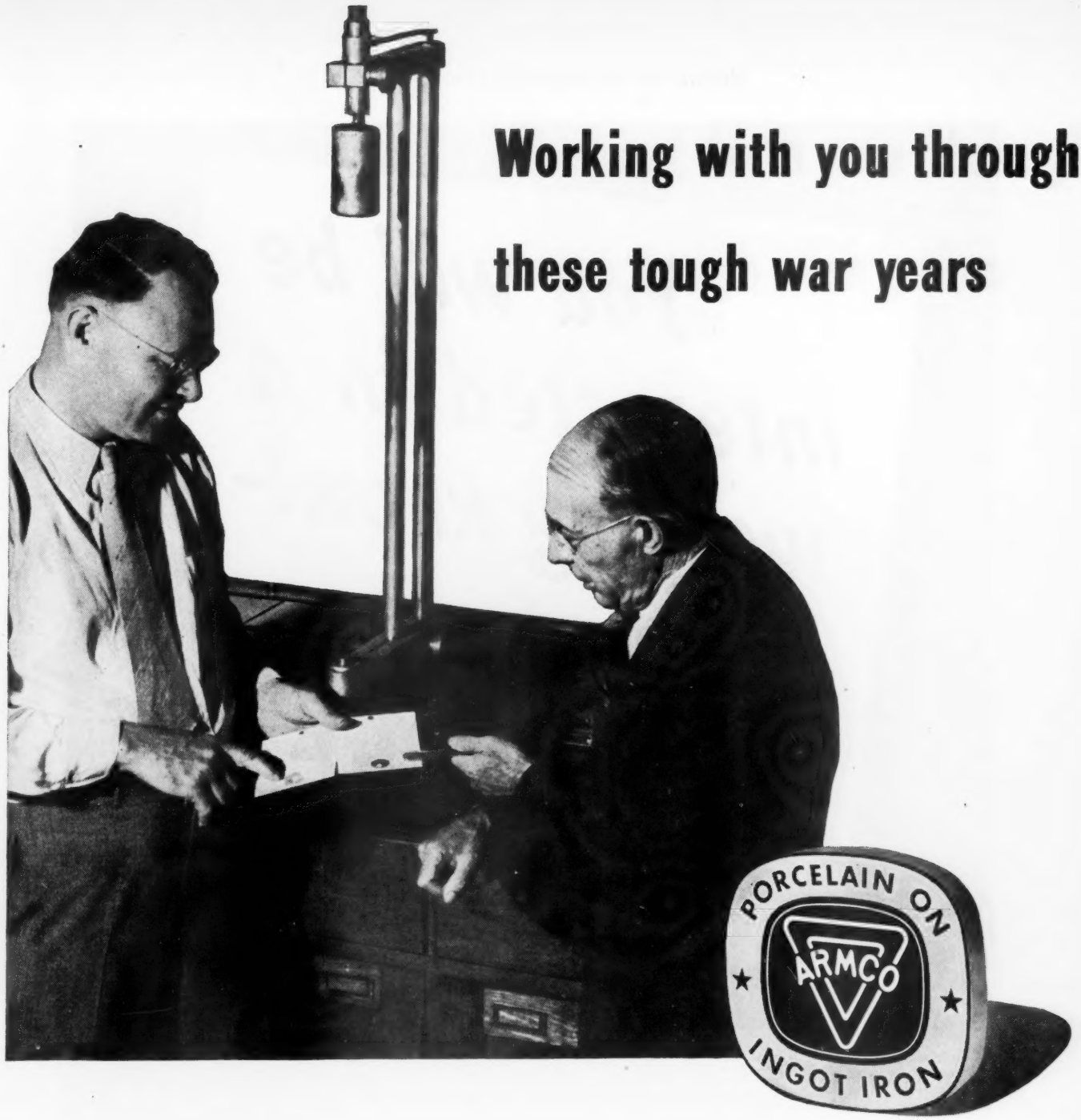

LONG before the war the Armco Porcelain Enamel Laboratory had a nation-wide reputation in the industry for developing constantly better enameling stock and for close co-operation with enamelers.

Preventing War Headaches. During these tough war years Armco service men have kept in touch with every one of their customers—helping them meet special needs, checking on designs, shop practice and other wartime problems.

Broader Service after War. Already Armco's field service organization is planning for even closer co-operation with enamelers after the war. They'll study the need before production starts—how flat the metal must be, how severely it must be drawn, what the physical properties must be, and much else. They will even help enamelers with special problems not necessarily related to enameling stock.

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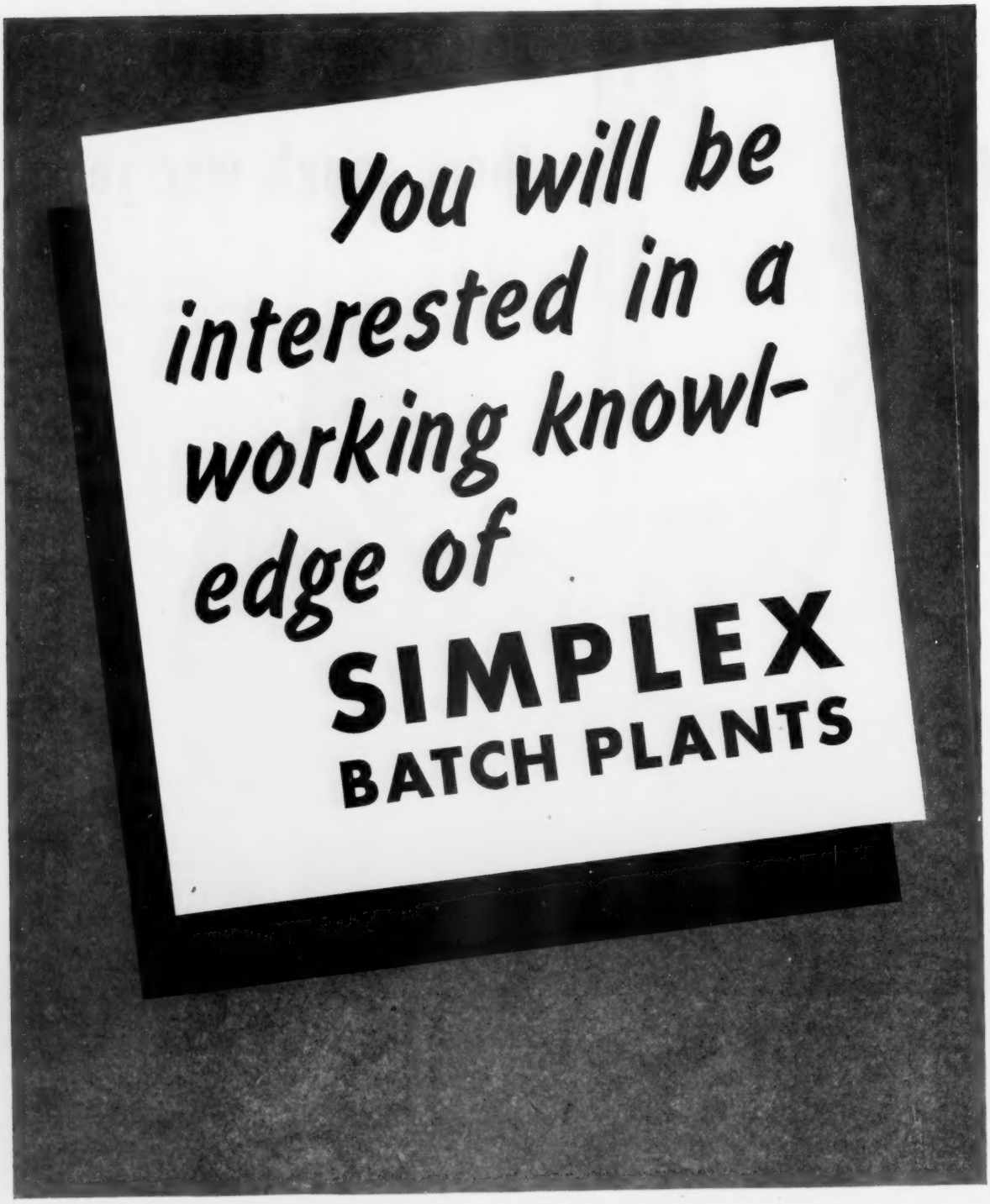

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?

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ALUMINUM														●					●		●
ANTIMONY														●							●
BARIUM				●					●				●		●		●		●		
BERYLLIUM					●					●	●		●								
CAESIUM			●	●	●	●			●			●									●
CALCIUM				●					●				●	●							●
CERIUM					●									●						●	
IRON				●									●	●	●		●	●			
LITHIUM	●	●	●	●	●		●		●	●			●			●					
MAGNESIUM				●												●					●
MANGANESE				●	●		●														●
SILICON							●							●				●	●		●
STRONTIUM				●	●	●			●	●											●
TELLURIUM													●		●						●
THORIUM							●														●
TITANIUM															●						●
TUNGSTEN					●									●	●						●
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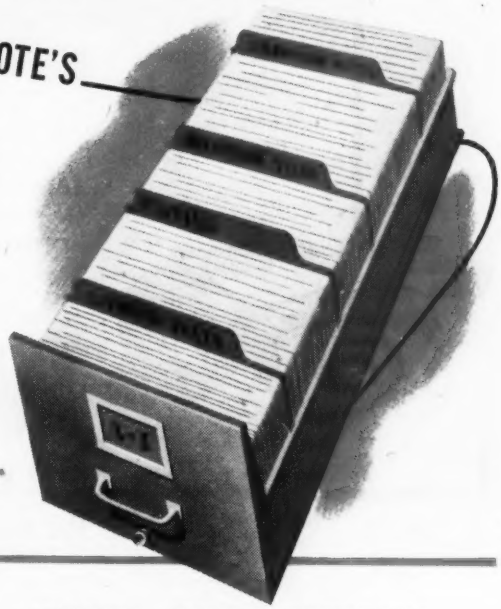

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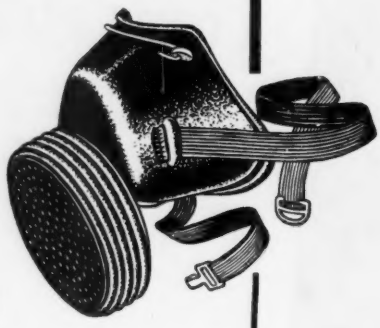

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23 U. S. Bureau of Mines approvals simply attest to the care in the development of respirators and gas masks designed and built to assure protection and comfort.

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FERRO LOOKS BACK *Briefly*

1919

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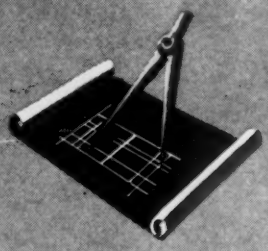
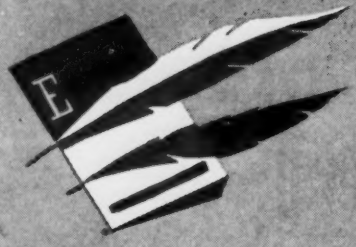
1 1919 . . . Ferro Enameling Co. founded, to produce porcelain enamel frit.

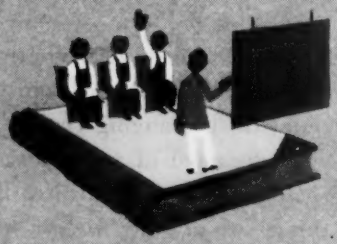
2 1920 . . . Ferro Enamel Supply Co. organized, to handle frit sales and engineering of plants and furnaces.

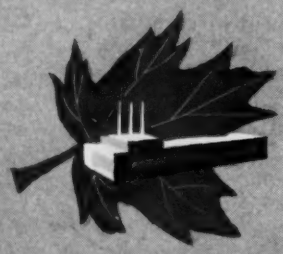




3 1923 . . The "Enamelist" published, first trade publication devoted exclusively to porcelain enameling.

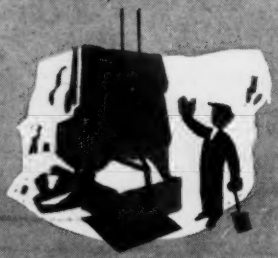
4 1926 . . . We publish a modern "handbook" on porcelain enameling; start the industry's first practical trade school.



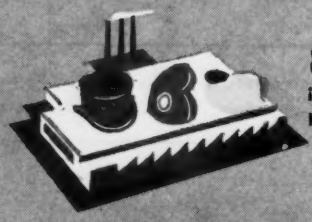


5 1927 . . . Subsidiary plant built in Canada to handle expanding Canadian business.

7 1930 . . . Ferro Enameling Co. and Ferro Enamel Supply Co. merge to form the Ferro Enamel Corporation.



6 1929 . . . Investigation and research started which later revolutionized porcelain enameling clays.

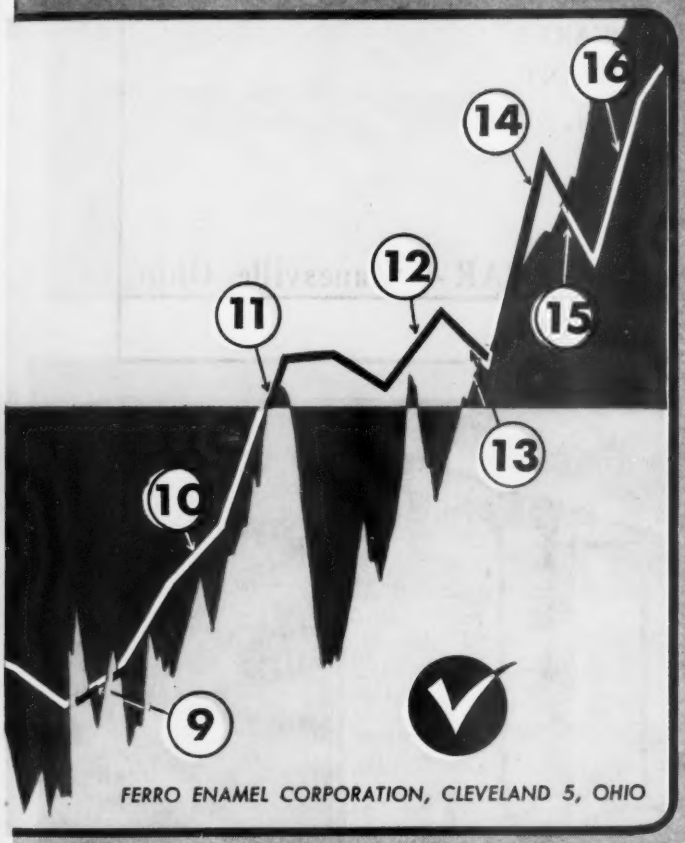


8 1930 . . . First European Subsidiary Plant built in Holland, later followed by plants in France and England.

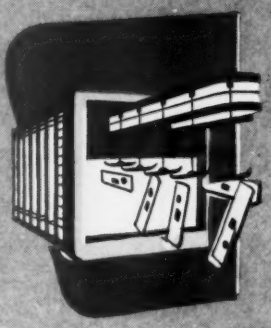
ON 25 YEARS OF PROGRESS

of our debt and obligation to our many loyal customers. So on this anniversary occasion we again want to express our thanks; also reassure our good friends that every effort will be directed toward meriting their continued support.

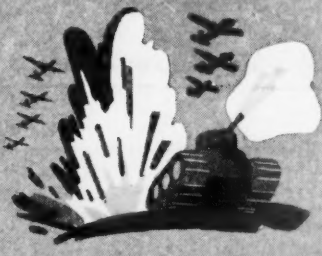
1944



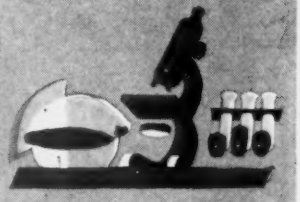
FERRO ENAMEL CORPORATION, CLEVELAND 5, OHIO



16 1943...Ferro announces revolutionary new frits and production techniques; also offers help in reconverting plants for peace.

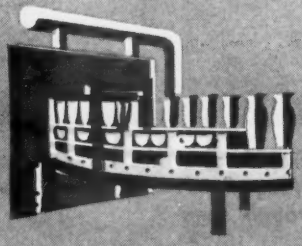


15 1942 . . . Extensive war contracts necessitate the building of new plants in Ohio, Alabama and California.

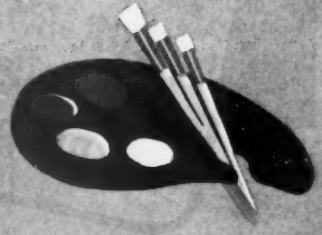


14 1941 . . . Ferro Drier & Chemical Company is organized. W. B. Lawson, Inc., an established sales organization, is acquired a year later.

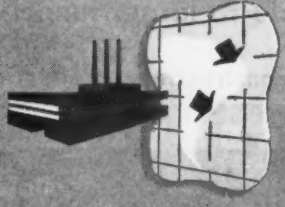
13 1940 . . . Liquid Plastics Division formed to produce fine-quality synthetic enamels and other industrial finishes.



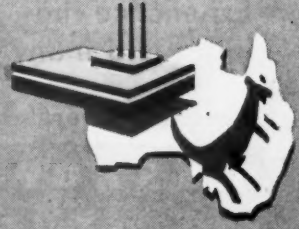
9 1933 . . Ferro enters pottery and allied ceramic field by acquiring Allied Engineering Co. and (later) the Ceramic Supply Co.



12 1939 . . . Color Division started, to manufacture oxides for porcelain enameling and glaze stains for the ceramic industry.



10 1935 . . . Subsidiary plant built in Brazil, followed by another subsidiary plant in Argentina.



11 1936 . . . Australian Subsidiary Company organized and plant built to handle Australasian business.

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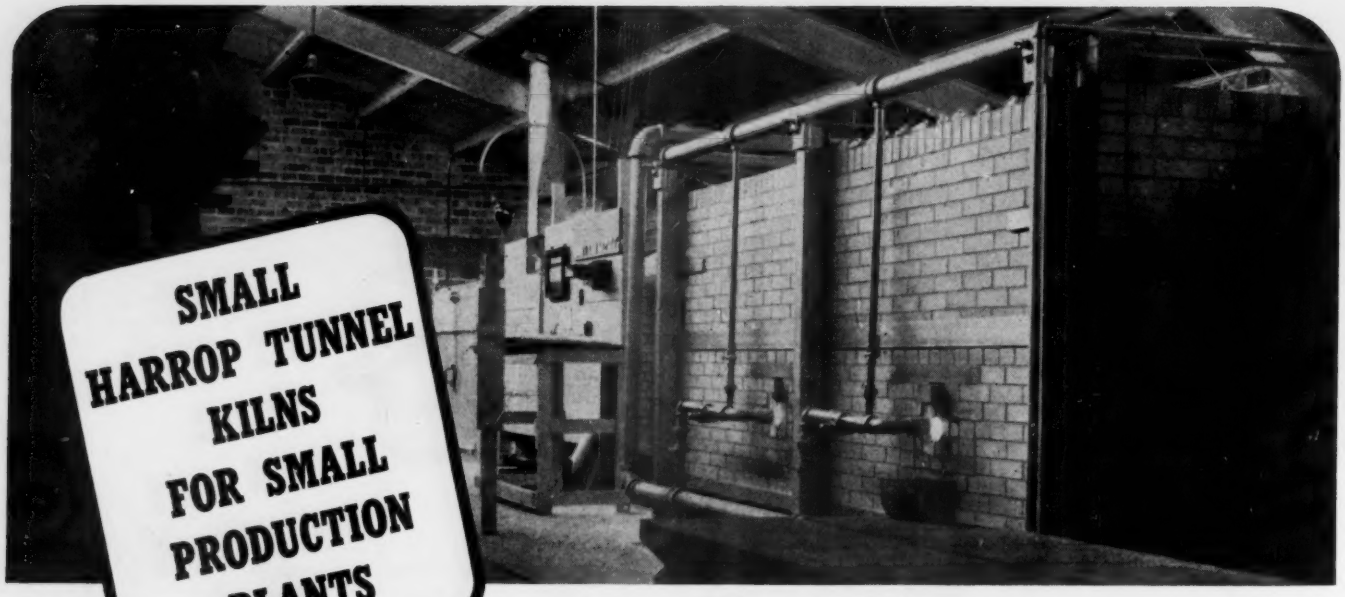

This Harrop kiln, in the W. I. Tycer Pottery, Roseville, Ohio, is 75 ft. long, fired with natural gas and is burning at temperatures through cone 9.

Experience has proved that the small Harrop Tunnel Kiln can effect fuel, labor and many other savings comparable to larger tunnel kilns in larger plants.

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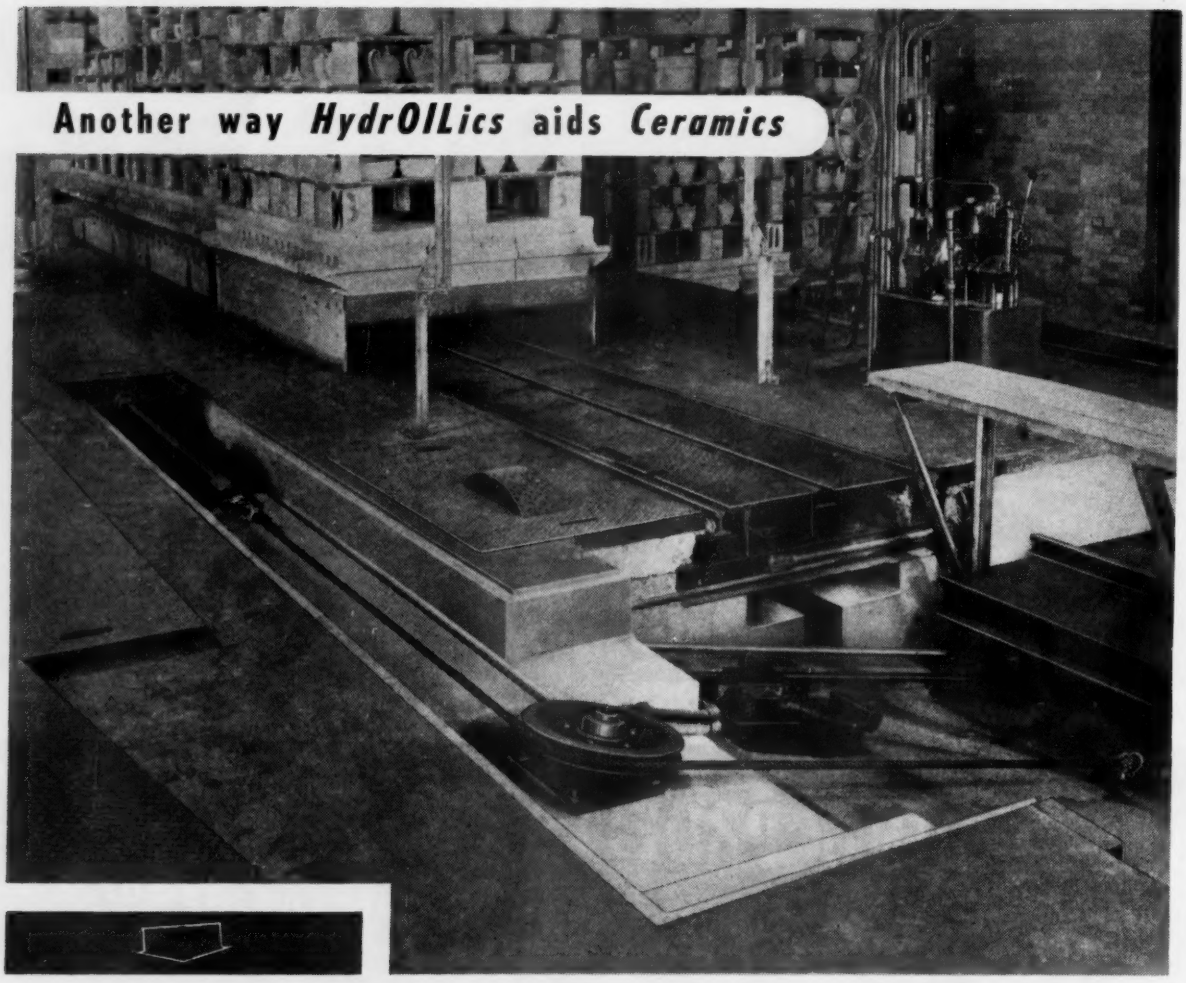

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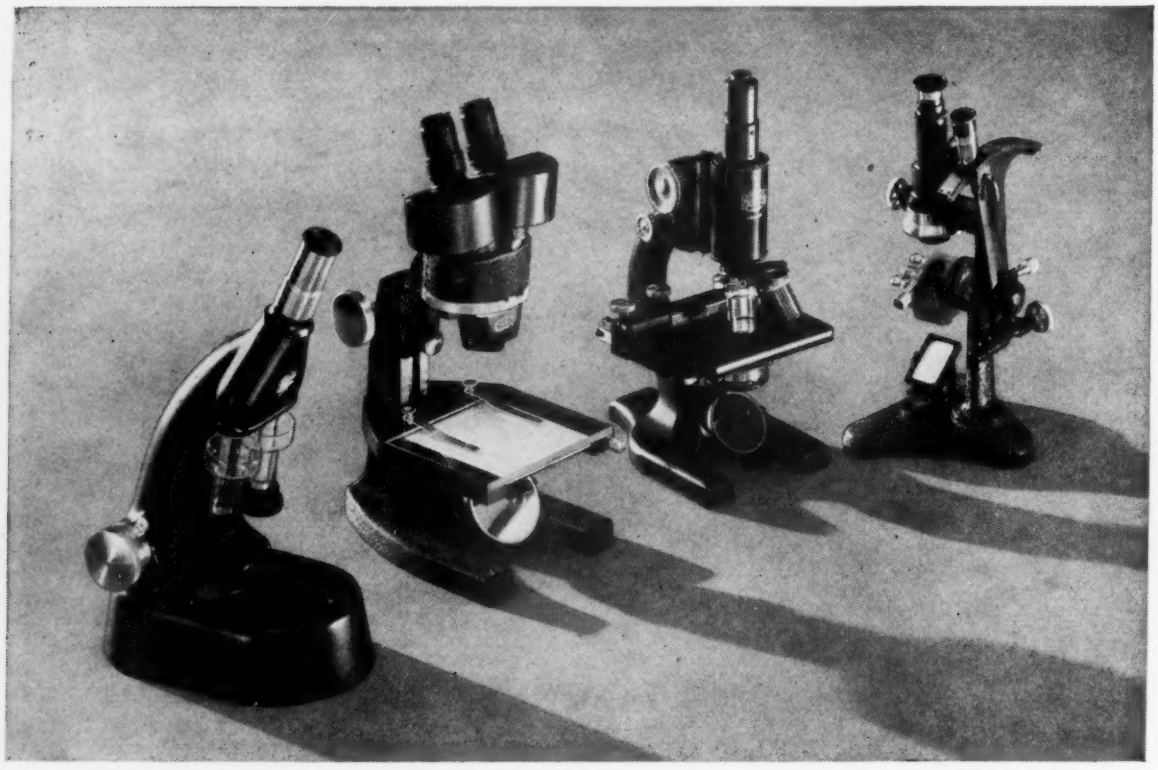

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Barium Carbonate
Bone Ash
Borax
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Chrome Green Oxide
Cobalt Oxide
Copper Oxide
Feldspar
Fluorspar
Gum Arabic
Gum Tragacanth
Hydrofluoric Acid
Iron Oxides
Magnesium Carbonate
Manganese Dioxide
Potassium Carbonate
Salt Cake
Selenium
Soda Ash
Sodium Antimonate
Sodium Nitrite
Sodium Silicofluoride
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Uranium
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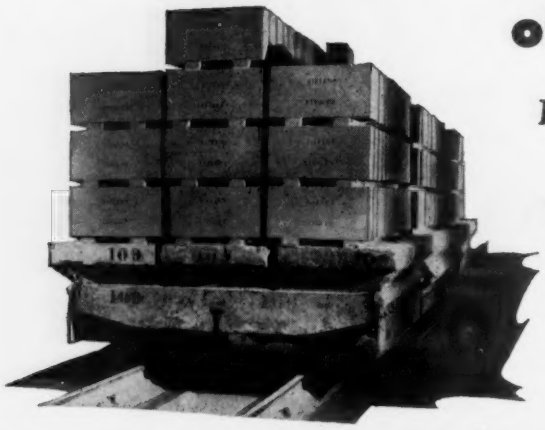
To Speed the Day

of Victory and Peace

Refractories are making possible the production of

TANKS · BOMBS · SHIPS



TO PRODUCE the vital implements of war, the industries of the United Nations must have fire brick and other refractory materials. Without fire brick to line the boilers and furnaces of industrial plants, heat could not be controlled for useful production. By means of refractories, crude ores are turned into the steel, copper, aluminum and magnesium that mean ships, tanks, airplanes, guns and ammunition. Gasoline and oil for our fighting forces are refined and made useful by the aid of fire brick. And the ships that must carry men and supplies to all parts of the world depend primarily upon refractories to make possible the creation of energy.

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PT BOATS: Marine engines for these raiders which help keep sea lanes open to American shipping are made of alloy steel from furnaces lined with fire brick.

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While Uncle Sam needs our materials and is getting them . . . the A. P. Green Fire Brick Company planned ahead — with plant expansion and the development of advanced methods of increasing production, to such proportions that greatly increased shipments have been made during the past year — actually 59% more than the previous high pre-war year — truly an outstanding job of supplying both the needs of our war effort and the requirements of our many regular customers.

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ON July 3, 1941, one of our customers started operation of a new Corhart balanced tank, melting flint bottle glass. After 860 days and 62,559.19 tons, the tank was shut down (on Nov. 11, 1943) for a 13-day partial repair.

At the time of this shutdown, the tank had produced 142.18 tons of glass per square foot, which in itself is a good record.

After the tank had cooled, however, careful inspection showed that the Corhart sidewalls and throat could be left intact for another campaign by overcoating at the metal line and making repairs to the superstructure. These repairs were made and the tank was started up again Nov. 25, 1943.

The operating data for the whole of the first period and for the second period up through May 31, 1944, is as follows:

Melting Area 440 Sq. Ft.	Total Days Life	Total Operating Days	Idle Days	Total Tons Flint Glass	Tons of Glass Per Sq. Ft. Per Life
7/3/41 to 11/11/43	860	844	16	62559.19	142.18
Down Period			13		
11/24/43 to 5/31/44 (Still Operating)	189	186	3	15613.58	35.48
TOTAL	1049	1030	32	78172.77	177.66

We will report to you, later, as to the outcome of this complete two-run campaign. As things appear now, we will be unable to give complete details until sometime in the first half of 1945.

Corhart Refractories Company, *Incorporated,* Sixteenth and Lee Streets, Louisville 10, Kentucky.

*Not a product, but a registered trade-mark.

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Ceramic Abstracts Section

Compiled by

THE AMERICAN CERAMIC SOCIETY

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PERIODICAL REFERENCE: The name of the periodical appears in italics, followed by the volume (bold-faced), issue number (in brackets), page numbers, and year (in parentheses).

Vol. 23 **October 15, 1944** **No. 10**

Abrasives

Step-by-step procedure for grinding ultrafinish rolls. H. J. WILLS. *Steel*, **109** [July 28] 78–80, 88 (1941); abstracted in *Jour. Iron & Steel Inst.*, **145** [1] 16A (1942).—W. describes the exact sequence of grinding operations, giving for each step details of the grinding wheel grit size, surface speed, traverse rate, and type of dressing. The method of grinding tungsten carbide rolls for Steckel mills is also given. See *Ceram. Abs.*, **22** [8] 131 (1943).

PATENTS

Abrasive article. R. L. MELTON AND A. L. BALL (Carborundum Co.). U. S. 2,355,667, Aug. 15, 1944 (Aug. 30, 1941).—A permanently charged abrasive polishing wheel of high flexibility comprising a plurality of felted layers of textile fibrous material having a major portion of the abrasive polishing material and a nonsmearing binder included internally throughout the individual fibrous layers.

Abrasive articles and method of making. G. P. NETHERLY, B. S. CROSS, AND G. R. ANDERSON (Minnesota Mining & Mfg. Co.). U. S. 2,357,348, Sept. 5, 1944 (March 20, 1941).—As a new article of manufacture, an abrasive article of the coated abrasive type comprising abrasive grains bonded with a polymerized monohydric alcohol ester of alkyl substituted acrylic acid.

Abrasive sheet material. J. H. KUGLER AND B. J. OAKES (Minnesota Mining & Mfg. Co.). U. S. 2,357,335, Sept. 5, 1944 (Oct. 29, 1938).

Abrasive tools and instruments. J. FERRARI. Brit. 562,294, July 5, 1944 (Nov. 26, 1943).

Abrasive wheels. NORTON GRINDING WHEEL CO., LTD. Brit. 562,468, July 12, 1944 (Dec. 1, 1941).

Abrasive wheels and method of making. NORTON GRINDING WHEEL CO., LTD. Brit. 562,467, July 12, 1944 (Dec. 1, 1941).

Apparatus for dressing grindstones. H. C. BARBOUR AND F. S. MILLER (Cleveland Quarries Co.). U. S. 2,355,844, Aug. 15, 1944 (June 9, 1943).

Centerless grinding or abrading machines. CHURCHILL MACHINE TOOL CO., LTD., AND H. LONGTHORPE. Brit. 562,362, July 12, 1944 (March 1, 1943).

Composite articles and abrasive belts or sheets. B. J. OAKES (Minnesota Mining & Mfg. Co.). U. S. 2,357,350, Sept. 5, 1944 (Sept. 2, 1939).

Device for holding and stropping or honing safety-razor blades. F. E. V. CURREY. Brit. 562,415, July 12, 1944 (Feb. 10, 1943).

Grinder attachment. C. A. OLSON, C. V. LISLE, AND T. E. BROOKS (Lisle Corp.). U. S. 2,356,175, Aug. 22, 1944 (Aug. 3, 1940).

Grinding machine. J. I. GARSIDE (Norton Co.). U. S. 2,356,394, Aug. 22, 1944 (Dec. 15, 1942). W. C. HEATH (A. O. Smith Corp.). U. S. 2,537,109, Aug. 29, 1944 (April 27, 1942). C. G. FLYGARE AND W. H. WOOD (Norton Co.). U. S. 2,357,510, Sept. 5, 1944 (Aug. 17, 1943). W. F. FRASER. U. S. 2,357,584, Sept. 5, 1944 (Aug. 29, 1940).

Honing machine. GEORGE CROMPTON, JR. (Norton Co.). U. S. 2,356,223, Aug. 22, 1944 (June 12, 1942). W. S. REYNOLDS AND J. R. TURNER (Remington Arms Co., Inc.). U. S. 2,356,272, Aug. 22, 1944 (April 28, 1943).

Knife sharpener. A. STAEHLI. Brit. 562,423, July 12, 1944 (March 8, 1943).

Making abrasive articles. H. V. ALLISON (Allison Co.). U. S. 2,356,965, Aug. 29, 1944 (May 12, 1943).—The method of making an abrasive article comprising mixing liquid styrene with the synthetic elastomer comprising the copolymer of butadiene and styrene to at least soften the latter, adding curing agents and abrasive grain, shaping articles from the mix, and then curing the shaped article and simultaneously therewith further polymerizing the liquid styrene to form a thermoplastic bond for the abrasive grain in the article.

Manufacture of abrasive-disk materials. R. L. MELTON AND R. C. BENNER (Carborundum Co.). U. S. 2,356,866, Aug. 29, 1944 (Oct. 6, 1941).

Polishing and buffing machine. G. A. CARLSON. U. S. 22,539, Sept. 5, 1944 (May 14, 1943); reissue of original U. S. 2,203,488, June 4, 1940 (June 30, 1938).

Shaft milling and grinding machine. O. D. PREMO. U. S. 2,355,750, Aug. 15, 1944 (Nov. 13, 1940; Oct. 17, 1941).

Vitrified diamond grinding wheel. R. H. LOMBARD (Norton Co.). U. S. 2,356,937, Aug. 29, 1944 (May 10, 1941).—A vitrified-bonded abrasive article comprising the bonded reaction product, as a result of firing, of a mix that comprises abrasive grains, metallic granules of metallic silicon, and vitrifiable bond, the metallic granules being present in the product in an amount, exclusive of any oxidation product formed during firing, to constitute substantially 15% by volume, or more, of the volume of the vitrified-bonded article and being bonded by and distributed throughout the vitrified bond thereby to reinforce the bond and to form with the vitrified bond a compound framework of metallic granules and vitrified bond material, of which the metallic granules are material structural parts, the abrasive grains being distributed throughout and supported by the compound framework and bonded therein by the vitrified bond of the framework.

Vitrified diamond grinding wheel. R. H. LOMBARD, (Norton Co.). U. S. 2,356,938, Aug. 29, 1944 (Jan. 6, 1942).—A vitrified-bonded abrasive article comprising the bonded reaction product, as a result of firing, of a mix that comprises abrasive grains, granules of an oxidizable boron compound, and vitrifiable bond, granules of the compound being present in the vitrified product in an amount, exclusive of any oxidation product formed during firing as a result of oxidation of some of the compound, to constitute a substantial proportion of the volume of the vitrified article and being bonded by and distributed in the amount throughout the vitrified bond thereby to reinforce the bond and to form with the vitrified bond a built-up framework of which the granules of the compound, in the substantial proportion, are material structural parts, the abrasive grains being distributed throughout and supported by the built-up framework and bonded therein by the vitrified bond of the framework.

Art and Archeology

Aesthetic measure applied to color harmony. P. MOON AND D. E. SPENCER. *Jour. Optical Soc. Amer.*, **34** [4] 234–42 (1944).—Applying the principle that beauty is order in complexity, the authors employ aesthetic measure in a numerical rating scheme to give a quantitative evaluation of the artistic merit of any given combination of colors. Such factors as identity, similarity, contrast, and ambiguity and area balance were evaluated by experiments with color chips. The results are summarized in a brief table of aesthetic factors, and instructions are given for the calculation of the aesthetic measure of any color combination. See "Geometric . . .," this page, and following abstract. A.P.

Area in color harmony. P. MOON AND D. E. SPENCER. *Jour. Optical Soc. Amer.*, **34** [2] 93–103 (1944).—The previous paper (see "Geometric. . .," this page) purposely ignored the effect of relative area of the color patches. Extension of the theory by taking area into account increases the aesthetic effect by bringing in additional elements of order. Two concepts are used: (1) *scalar moment* of a color patch about the adaptation point in space, and (2) *balance point* of a set of colors. A pleasing sense of balance is obtained when all the color patches have equal scalar moments and also when the moments are simple multiples of each other. Balance point is useful in determining the general psychological effect of a harmony. In practice, the designer first selects hues appropriate to the application, then chooses the type of harmony, and selects either large or small color steps, avoiding the regions of ambiguity. Areas are then determined by the methods given in this paper and adjusted so that the scalar moments of the various color patches are equal. If one of the colors is to be emphasized, its area can be increased to two or three times the moment of the other color patches. Finally the designer calculates the balance point and decides if psychological effects require modification of colors. All this is done by simple mathematics without the use of any colorants. When the areas are given, application of the same principles suggests the best colors. The new method does not stultify artistic ability but reduces the time spent in groping for a satisfactory color arrangement. (See preceding abstract.) A.P.

Color designations for lights. K. L. KELLY. *Jour. Optical Soc. Amer.*, **33** [11] 627–32 (1943); see *Ceram. Abs.*, **23** [3] 50 (1944). A.P.

Concept of color. Report of Committee on Colorimetry, Chapter II. *Jour. Optical Soc. Amer.*, **33** [10] 544–54 (1943).—The nature of radiant energy and the processes by which it is radiated, modified, and detected are described. A.P.

Final report of the O.S.A. Subcommittee on the Spacing of the Munsell Colors. S. M. NEWHALL, D. NICKERSON, AND D. B. JUDD. *Jour. Optical Soc. Amer.*, **33** [7] 385–418 (1943).—A modified and enlarged Munsell solid has been evolved from the 1940 visual estimates of the Munsell Book of Color samples. All three dimensions have been carefully reviewed and extensively revised. A solid is achieved which approaches more closely A. H. Munsell's dual ideal of psychological equispacing and precise applicability. See *Ceram. Abs.*, **20** [3] 62–63 (1941). A.P.

***Fundamental quantities and terms in the field of light absorption.** A. THIE. *Z. Elektrochem.*, **48** [5] 237–70 (1942).—Definitions as given in the German DIN 5031 and 1335 relative to the absorption of light and the formation of heat and photolytic products are discussed, and applications for fundamental laws are described. M.HA.

Further study of ω space. J. L. SAUNDERSON AND B. I. MILNER. *Jour. Optical Soc. Amer.*, **34** [3] 167–73 (1944).—A method for comparing colors on a mathematical basis, such as is attempted by Moon and Spencer in their ω space (see "Metric based . . . ," this issue), has important applications from the industrial standpoint in the field of color. Such a method would be useful for the specification of color tolerances, color differences, and color changes. The ω space does not appear to be a sufficiently accurate mathematical description of the Munsell color space to deserve wholehearted acceptance for some purposes by colorists in industry. The distortion at the higher chromas appears too serious to ignore, and further investigation is also needed of the relation between a chroma change and a value change. A.P.

Geometric formulation of classical color harmony. P. MOON AND D. E. SPENCER. *Jour. Optical Soc. Amer.*, **34** [1] 46–59 (1944).—Classical theories of color harmony are developed scientifically by incorporating the qualitative ideas of artists and color specialists into a quantitative system depending on the C.I.E. color specification and its transformation into a metric color space. The theory is based on two postulates: (1) pleasing intervals and ambiguous intervals exist between colors; and (2) any geometric arrangement of colors that can be sensed as orderly will be pleasing. A detailed classification of harmonies is tabulated. The method gives the designer a wealth of new harmonies which he can use as a tool to obtain the desired effect more directly. See "Area. . .," and "Aesthetic. . .," this page. A.P.

Graphical representation of small color differences. W. D. WRIGHT. *Jour. Optical Soc. Amer.*, **33** [11] 632–36 (1943).—Attention is drawn to the personal variations that have been found in the sensitivity of the eye to small color differences, which suggest that the simpler linear projection of the C.I.E. chromaticity diagram may prove adequate as a uniform chromaticity chart. D. L. MACADAM. *Ibid.*, [12] 675–79.—Wright's proposed diagram may serve many useful purposes, but projective transformations are fundamentally inadequate for uniform

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* From microfilm.

representation of the experimental facts. See "Projective . . .," *Ceram. Abs.*, **21** [6] 118 (1942). A.P.

Historical background and evolution of the colorimetry report. L. A. JONES. *Jour. Optical Soc. Amer.*, **33** [10] 534–43 (1943).—J. surveys the historical background and general evolution of the report on which a committee of the Optical Society has been working for ten years to bring order into the definitions and concepts of color and to provide useful data. A.P.

Metric for color space. P. MOON AND D. E. SPENCER. *Jour. Optical Soc. Amer.*, **33** [5] 260–69 (1943).—A metric, or measure of minimum perceptible color difference, for color space is developed by transforming the C.I.E. color space into a three-dimensional space in which the differences are represented by small spheres of the same size throughout the space. The new space representation has important applications in color discrimination and color tolerances and gives for the first time a mathematical method of comparing colors which differ both in quality and in quantity. The new system does not replace, but only supplements, the C.I.E. system. A.P.

Metric based on a composite color stimulus. P. MOON AND D. E. SPENCER. *Jour. Optical Soc. Amer.*, **33** [5] 270–77 (1943).—The method presented in a previous paper (see preceding abstract) does not apply to problems dealing with large color steps such as are encountered in color harmony. A metric space is now derived, called ω space, based on the Munsell data and taking adaptation into account. In ω space the Munsell curves of constant hue appear as straight lines, and the curves of constant chroma are uniformly spaced circles. See "Further . . . ," this issue. A.P.

Physical concepts: radiant energy and its measurement. Report of Committee on Colorimetry, Chapter V. *Jour. Optical Soc. Amer.*, **34** [4] 183–218 (1944).—The following factors are considered: (1) the definitions of the quantities and units employed for the specification of radiant energy in its various manifestations, and the capacities of materials and objects to radiate, modify, and detect radiant energy; and (2) the fundamental principles and a description of suitable apparatus and methods for the measurement of such quantities. A.P.

Psychological color solid. D. NICKERSON AND S. M. NEWHALL. *Jour. Optical Soc. Amer.*, **33** [7] 419–22 (1943).—In the preparation of a report on the smoothing of the Munsell colors, data have become available that permit an approximate fulfillment of the four requirements for an ideal psychological solid in cylindrical coordinates. Two models were constructed: (1) for colors perceived under good visual color-matching conditions such as those of a textile color matcher, and (2) for colors perceived under optimum conditions, as when using a good instrument. With model 2, about 7,500,000 surface colors may be distinguished. Solid 1 is one-quarter as high, and approximately 1,875,000 colors can be distinguished in visual color matching. A.P.

Psycophysics of color. Report of Committee on Colorimetry, Chapter VI. *Jour. Optical Soc. Amer.*, **34** [5] 245–66 (1944).—The Committee's report defines the concepts of light and color and states the distinction between them and the concepts related to them in the fields of psychology and physics. A.P.

Symposium on the Ostwald color system: Foreword. D. B. JUDD. *Jour. Optical Soc. Amer.*, **34** [7] 353–54 (1944).—Despite its scientific limitations, the Ostwald color system has led to color charts which have had considerable use here and in Europe. This symposium aimed to present sympathetically a factual summary of the Ostwald color theory and its implications, together with technical and practical evaluation of the most recent set of color standards arranged according to that theory. **Philosophy of the Ostwald color system.** H. ZEISHOLD. *Ibid.*, pp. 355–60.—The Ostwald system deals only with the colors of objects. It seeks a connection between the reflectances of the objects and their colors such that the resulting color scales shall have equal steps of equal visual distances. The scale of grays is proportioned to the logarithm of reflectance. The chromatic scales are based upon the Ostwald theory of semichromes, which postulates that the most chromatic object color (full color) of any given hue is associated either with a surface of 100% reflectance between two complementary wave lengths and zero for other wave lengths or with the converse. Other chromatic colors are classified as equivalent to admixtures of black and white to the full color of the same hue and are represented in the constant-hue triangle according to the equation, full-color content plus white content plus black content equals unity. Variations parallel to the white–full color side of the triangle are known as isotones; those parallel to the black–full color side are isotints; and those parallel to the black-white side are the isochromes or shadow series. **Analysis of the Ostwald color system.** C. E. FOSS, DOROTHY NICKERSON, AND W. C. GRANVILLE. *Ibid.*, pp. 361–81.—After presenting some of the Ostwald concepts, the ideal Ostwald color solid is developed in terms of modern colorimetry, and material representations of the system are related to the ideal. The Ostwald method of relating all object colors to admixtures of ideal full color, ideal white, and ideal black leads to a systematic series of ideal spectrophotometric curves made up simply of two vertical and two or three horizontal lines. The vertical lines correspond to complementary wave lengths. The upper horizontal corresponds to a reflectance differing from unity by an amount indicating the black content, and the lower horizontal line or lines correspond to a reflectance indicating the white content. Colors of constant Ostwald hue correspond to constant dominant wave length; the isochromes correspond to constant chromaticity (dominant wave length and purity constant). 68 references. **Colorimetric specification of the Color Harmony Manual from spectrophotometric measurements.** W. C. GRANVILLE AND E. JACOBSON. *Ibid.*, pp. 382–95.—In 1942 the Color Harmony Manual, comprising 680 color chips, was published with the hope of promoting the knowledge and study of color harmony, to be a tool for the color designer, and to serve as scientific color standards (see *Ceram. Abs.*, **21** [10] 206 (1942)). Spectrophotometric curves of these chips have been converted into standard colorimetric specifications so that users of the Manual may have precise information regarding these colors. The data are given in such a form that the degree of conformity to Ostwald principles and to previous Ostwald scales can be judged. **Application of the Ostwald color system to the design of consumer goods.** FABER BIRREN. *Jour. Optical Soc. Amer.*, **34** [7] 396–99 (1944).—The application of set rules of color harmony is not enough for the stylist or designer. The broad principles of the Ostwald system, however, are valuable guides to combinations of colors pleasing to the general public. Color is seen not primarily in terms of value and chroma, lightness and darkness, but as an admixture of full color, black, and white. The isovalent colors having the same white and black content are generally more pleasing than the same hues at constant lightness. The isotint and isotone series are delightful for their orderliness alone, but particular importance is attached to the isochrome or "shadow series" whose virtue in the sphere of painting was discovered by Leonardo da Vinci. No system of color harmony need be accepted as final and omnipotent, because color theory is fluid and changing. A.P.

Trichromatic specifications for intermediate and special colors of the Munsell system. W. C. GRANVILLE, DOROTHY NICKERSON, AND C. E. FOSS. *Jour. Optical Soc. Amer.*, **33** [7] 376–85 (1943).—About 1000 colors representing intermediate or special series added to the basic Munsell colors were measured spectrophotometrically, and colorimetric values were computed from the curves. A.P.

Tristimulus specification of the Munsell Book of Color from spectrophotometric measurements. K. L. KELLY, K. S. GIBSON, AND D. NICKERSON. *Jour. Optical Soc. Amer.*, **33** [7] 355–76 (1943).—Development of the Inter-Society Color Council—National Bureau of Standards (ISCC–NBS) system of color names, based on the standards in the Munsell Book of Color, made it necessary to

specify the master standards of this book in fundamental terms. Spectral reflection curves were run for each of the 421 master standards. After standard corrections were applied, colorimetric computations were made with these data for four illuminants. The derived chromaticity diagrams serve as means for determining the Munsell notation and thereby the ISCC-NBS color name for any color whose trilinear coordinates and apparent reflectance are given. A.P.

PATENTS

Bottle design. W. C. TEUNISZ. U. S. 138,663, Aug. 29, 1944 (June 14, 1944). W. F. SMITH (Kimble Glass Co.). U. S. 138,686, Aug. 29, 1944 (Nov. 5, 1943).

Color-marking element. M. A. FERST AND C. F. WYSONG (M. A. Ferst, Ltd.). U. S. 2,355,638, Aug. 15, 1944 (May 1, 1943).—A color-marking element comprising a friable ceramic body including fired clay and a nonplastic hydrous silicate, the body having pores filled with a coloring impregnant.

Composite glass and ceramic article and method of making. W. C. GREGORY. U. S. 2,357,399, Sept. 5, 1944 (Jan. 13, 1942).—The method of making a composite glass and ceramic article which comprises forming a base member having a cavity therein out of a wet moldable ceramic material, filling the cavity to a substantial depth with a glassforming material, heating the base member and the material to fire the base member and to form a mass of glass of substantial thickness fused to the bottom of the cavity, and cooling the base member and the glass.

Design for drinking glass, etc. A. J. F. ERBE. U. S. 138,627 to 138,639, Aug. 29, 1944 (May 18, 1944).

Pencil lead. M. A. FERST AND C. F. WYSONG (M. A. Ferst, Ltd.). U. S. 2,355,639, Aug. 15, 1944 (May 19, 1943).—The process of producing graphitic marking elements which comprises preparing a mixture including graphite, bonding material, and a discrete distending material; forming a marking element thereof; firing the thus-formed element; subjecting the element, at some stage subsequent to the forming operation, to treatment acting to reduce the volume of the distending particles; and filling the thus-formed pores with an impregnant.

Cements

Calcination control for high-calcium and magnesium limes. VICTOR J. AZBE. *Rock Products*, **47** [7] 53–54, 74–75 (1944).—The nonuniform temperature in limekilns results in improperly calcined lime, part of which may be underburned and/or overburned, thus affecting adversely the properties desired for chemical purposes. With dolomitic limes, higher temperature and longer time of exposure in the kiln promote the growth of the MgO crystals. Lower calcination temperatures result in smaller crystals of MgO together with many small crystals of $Mg(OH)_2$. CaO tends to form in small porous crystals. With the use of the Azbe controlled-calcination process, a readily hydrated lime may be produced. Operation of the Azbe recirculating kiln is described. B.C.R.

How much do we know today about cements? A. J. BLANK. *Pit & Quarry*, **37** [1] 73–74, 104–105 (1944).—B. discusses the existing books pertaining to cements and compares modern theories with older ones. He concludes that most subjects have been treated long ago and rehashed over a long period of years. Little, if anything, concerning cements is known today that was not known and discussed years ago. M.R.

Hydration and hardening of Portland cement. G. A. ASH. *Pit & Quarry*, **37** [1] 79–82 (1944).—A. summarizes authoritative opinion on the principles of cement hardening and hydration. In his opinion the "gel" theory continues to present a workable explanation of these principles, but important problems concerning the hardening of cement mixed with aggregates, the causes of volume changes in concrete, and their relations to the bond strength are awaiting a coherent theory. 17 references. M.R.

Mechanism of the destruction of concretes by sulfate-rich waters. G. BATTA. *Rev. Universelle Mines*, **19**, 98–107 (1943); abstracted in *Chem. Zentr.*, **1943, II** [13] 1220.—Theories of the destruction of concrete by sulfate-containing water and sea water are reviewed, and experiments made to determine the chemical resistance of various cements are described. The effect of sulfate solutions is characterized either by swelling or by the dissolving of the "active" constituent out of the cement. Swelling is measured by the Le Châtelier needle, while the dissolving effect and the tendency to corrosion were measured by indices which made a distinction between different cements possible. M.HA.

Universal-Atlas research activities carried on in modern laboratories. ANON. *Pit & Quarry*, **37** [1] 94–98, 100 (1944).—The research laboratories of the Universal-Atlas Cement Co., located at the Buffington, Ind., plant, are composed of seven interconnected sections or groups known as the analytical, petrographic, concrete, cement-products, and oil-well-cement laboratories and the experimental plant. The staff and work of each group and some of the more important or specialized equipment in the laboratories are briefly described. 14 photographs. M.R.

PATENT

Manufacture of self-hardening cementitious products. SEMTEX, LTD., L. H. GRIFFITHS, AND W. SAUL. Brit. 562,268, July 5, 1944 (Sept. 3, 1942).

Enamel

Answer to the erection problem for architectural porcelain enamel. M. VAN DER KLOET. *Finish*, **1** [8] 17–20 (1944).—K. expresses the need for instruction in the erection of porcelain enamel of architects, contractors, and building-trade craftsmen. A possible plan is outlined. W.R.B.

Appliances for tomorrow. J. GORDON LIPPINCOTT. *Finish*, **1** [8] 9–12 (1944).—The viewpoints of an industrial designer concerning future appearance, utility, and construction of ranges, heaters, refrigerators, washers, and bathroom appliances are given. Illustrated. W.R.B.

Ceramic finishes in wartime housing. GEORGE S. BLOME AND GEORGE WIESE. *Finish*, **1** [8] 13–15 (1944).—New uses for enamel finishes in wartime housing are dealt with. Porcelain enamel flues and tent hoods and their manufacturing processes are described. Possibilities of postwar use are suggested. W.R.B.

How and why of sign advertising: V, Sign copy. KEN M. DAVEE. *Finish*, **1** [8] 21–23 (1944).—The writing of sign copy, i.e., the selection of words, is discussed in detail. For Parts **III** and **IV** see *Ceram. Abs.*, **23** [9] 149 (1944). W.R.B.

Improved quality in porcelain enamels. E. E. HOWE. *Better Enameling*, **15** [7] 4–9 (1944).—The thinnest enamel coating consistent with salability is the most durable. The development of enamels with increased covering power resulted from the invention of instruments and techniques for measuring the opacity of the cover-coat enamel. Other factors resulting in improved ware are pure raw materials, better control of the consistency of enamel, automatic instrument control, and improved base metal, design, and fabrication and processing methods. B.C.R.

Properties of enamel slips: I, General properties of clays and enamel slips. BURNHAM W. KING, JR., HER-

BERT D. CARTER, AND HARRY C. DRAKER. *Jour. Amer. Ceram. Soc.*, **27** [9] 253–60 (1944).—4 references, 16 figures.

PATENTS

Application of vitreous enamels. EXPRESS LIFT CO., LTD., AND L. E. W. WELLS. Brit. 562,225, July 5, 1944 (March 1, 1943).

Combination bathroom structure. L. W. HELMUTH (Midland Steel Products Co.). U. S. 2,355,615, Aug. 15, 1944 (March 16, 1940).

Glass

Calculator for computing the spectral transmission of glasses at different thicknesses. T. C. VAUGHAN. *Glass Ind.*, **25** [6] 259, 278–79 (1944).—Circular scales reproduced in exact calibration are given as patterns for the construction of a calculator for computing the spectral transmissions of colored glasses for various thicknesses. A.P.

* **Cation field intensities and their relations to devitrification phenomena, to the formation of compounds, and to the melting points of silicates.** A. DIETZEL. *Z. Elektrochem.*, **48** [1] 9–23 (1942).—The properties of glasses and the influence of the various glass constituents can, at present, be best described by the field intensities of the cations involved in relation to their distance from the anion; a table for field intensities is given for the glass technically important elements. A study of the binary silicate, borate, and phosphate systems shows that homogeneous glasses or crystallized compounds are formed only when the field intensity of the foreign cation as compared with the intensity of Si^{4+}, B^{3+}, and P^{5+} is sufficiently large; if the difference of the field intensities becomes too small, demixing or separation of the system into two liquid phases or the two oxides can easily occur. A rule was established stipulating that ternary compounds can be formed only when the difference in the field intensities for the involved cations is >0.05. Below this value, only simple eutectic systems or solid solutions exist. These rules hold good not only for silicate systems but also for ordinary salts such as chlorides, sulfates, carbonates, and nitrates. The relations found permit certain predictions for still unknown ternary systems; e.g., no ternary compound can be expected in the system Li_2O–BaO–SiO_2, but one can in the system Li_2O–K_2O–SiO_2. By means of the field intensities (z/a^2, where z = valency, a distance between ions), the highest stages of acidification (y_{max}) can be determined. The value $y_{max} = 0.36/(z/a^2)$ indicates how many moles of SiO_2 can maximally be bound to $1/n$ mole of an oxide, R_mO_n, whose cation has the field intensity z/a^2; the compound formed melts congruently. For compounds with incongruent melting behavior, the formula is $y_{max} = 0.36/(z/a^2) + 0.5$. M.HA.

Colorful Fiberglas fabrics seen ending inflammable drapery fire hazard. LEON CHASTEL. Read at meeting of Institute on Textiles and Clothing, Michigan State College, July, 1944; abstracted in *Amer. Glass Rev.*, **63** [42] 19 (1944). A.P.

Development of bifocal lenses. ALBERT BARNETT. *Optician*, **107** [2770] 195–96 (1944).—Benjamin Franklin (1777) devised the first bifocal spectacles, two half-circular lenses divided horizontally through their centers. Later inventors (1) introduced hinged double spectacles which could be raised (1783) or turned back against the temples (1797); (2) placed Franklin's lower half at an angle (1834); (3) used double grinding to give a shallower curve on the upper half of a stronger convex lens (1836); (4) ground a concave depression in the center of a plano-convex lens (1863); (5) cemented bifocals (18—); (6) fitted a segment cut from a stronger lens into an elliptical space in the lower part of the lens (1888); (7) cemented glasses of two different refractive indices (about 1905); (8) cemented the segments between two layers of crown glass; and (9) fused flint glass to crown glass. Many improvements have been developed in both the one-piece and fused bifocals. Experiments are being conducted with plastic bifocals. A.P.

Effect of chemical composition on the coloration of glasses colored with neodymium oxide. V. ČTYROKÝ. *Sklářské Rozhledy*, **20**, 81–85 (1943); abstracted in *Chem. Zentr.*, **1943, II** [13] 1219.—The following glasses colored with neodymium oxide were investigated with regard to change of color under different spectral illumination (daylight, incandescent lamps) and at different thicknesses: lead glass (**I**), 56 SiO_2, 26.0 PbO, 1.3 Na_2O, 15.2% K_2O; baryta glass (**II**), 56.0 SiO_2, 26.0 BaO, 1.3 Na_2O, 15.2% K_2O; zinc glass (**III**), 56.0 SiO_2, 26.0 ZnO, 1.3 Na_2O, 15.2% K_2O; borosilicate glass (**IV**), 60.0 SiO_2, 12.3 B_2O_3, 7.1 CaO, 1.6 Na_2O, 17.5% K_2O; lime glass (**V**), 68.0 SiO_2, 10.0 CaO, 5.0 Na_2O, 15.5% K_2O; all glasses contained 1.5% Nd_2O_3, were 10 mm. thick, and were polished for spectrophotometric measurements. In the range of 400 to 600 mμ, the glasses show increasing absorption in the order **V, IV, II, I, III**; the same holds good for the range 600 to 720 mμ with slight differences. The absorption maxima and minima between 560 and 600 mμ also show differences, a higher maximum at 570, a lower one at 590, and a minimum at 580 mμ; the differences between maximum and minimum are greatest in **V** and least in **III**. The sudden color change from 5 to 30 mm. glass thickness took place in decreasing degree in the order **V, IV, II, I, III**. The sudden color change under daylight to incandescent light is strongest in **V** and weakest in **III**. The **III** glasses, however, are always most intensely colored and the **V** glasses the most weakly, the order being **III, I, II, IV, V**. M.HA.

Fiberglas wool is used in infantile paralysis treatment. ANON. *Amer. Glass Rev.*, **63** [43] 9 (1944).—Glass-wool blankets for the Kenny Pack treatment of infantile paralysis are being experimented with in the Elmira, N. Y., hospitals. They are expected to prove more applicable than the ordinary blanket of wool. To make them more water repellent, they may be treated with a silicone. A full blanket would weigh about 9 oz., comparable to eiderdown. A.P.

Glass-asbestos textile. ANON. *Chem. & Met. Eng.*, **51** [5] 157 (1944).—By combining glass and asbestos fiber, a new textile has been developed by the Owens-Corning Fiberglas Corp. that provides high strength with light weight, high abrasion resistance, and resistance to high temperatures and corrosive fumes. B.C.R.

Laminated plate glass goes into aircraft cabin assembly. ANON. *Amer. Glass Rev.*, **63** [40] 30–31 (1944).—Seven photographs show the assembly of the glass for the cabins of an A-25 attack bomber at the Crystal City plant of the Pittsburgh Plate Glass Co. The windshield and movable side panels are made of three-ply bent Flexseal safety glass. Behind the windshield a 1.5-in. Multiplate protects the pilot from bullets. A.P.

New square milk bottle of Owens-Illinois Glass Co. proves worth. ANON. *Amer. Glass Rev.*, **63** [42] 7 (1944); *Food Inds.*, **16** [8] 83 (1944).—The Handi-Square milk bottle of Duraglas with Econopor finish, designed and manufactured by the Owens-Illinois Glass Co., has proved very satisfactory after one year of service with an Iowa dairy firm. The square bottle weighs 17.75 oz. and is nearly 1 in. shorter than the straight-neck bottle. Carrying cases are one-third smaller and 20% lighter. Space is saved in delivery trucks, home refrigerators, and grocers' shelves. A.P. & M.R.

Optical glass history. W. N. WHEAT. *Optician*, **107** [2770] 203–204 (1944).—W. calls attention to the little-recognized work on optical glasses by W. Vernon Harcourt from 1834 to 1860, described in British Assn. Reports for 1871 by Stokes. In addition to the usual glassmaking oxides of the time, Harcourt employed the oxides of lithium, barium, strontium, beryllium, magnesium, aluminum, zinc, cadmium, tin, lead, thallium, bismuth, anti-

* From microfilm.

mony, vanadium, etc., in combination with phosphates, borates, fluorides, tungstates, molybdates, and titanates. Abbe and Schott knew of this work, and Schott's new glasses owed much to the inspiration of Harcourt's pioneer work. A.P.

Pictorial review of glass at war. ANON. *Amer. Glass Rev.*, **63** [40] 33–39 (1944).—Photographs illustrate (1) foam glass for life rafts, (2) a solar signaling mirror, (3) all-glass kitchen, (4) woman molding optical blanks, (5) welding metal to glass, (6) glass reinforced plastic fuselage fabrication, (7) Army plane with glass-plastic fuselage, side panels, and tail cone, (8) shaping glass tube for fuel line of auxiliary gasoline tanks, (9) glass ring jewels for aircraft instrument bearings, (10) glass parts for electronics, (11) thermal conductivity test panel at new Owens-Corning laboratory, (12) microprojector used to check fiber diameters at the same laboratory, and (13) glass-fiber packing in an alcohol-distillation column. A.P.

Pittsburgh Plate producing necessities for war. ANON. *Amer. Glass Rev.*, **63** [40] 40 (1944).—From the plants of the Pittsburgh Plate Glass Co. during World War II has flowed a wide variety of glass products designed to sharpen the efficiency of weapons and safeguard lives. A.P.

***Porous glass.** PAUL H. PRAUSNITZ. *Kolloid-Z.*, **104**, 246–54 (1943).—In recent years the term "porous glass" usually has referred to sintered-glass filters and similar devices. Actually, the sintered or fritted glass apparatus was first made in 1923, whereas porous glass has been known since antiquity; before the development of the glass blower's pipe, this was the only known way to make glass. Porous glass is also produced by nature, as exemplified in pumice. Recently, it has been possible to produce artificial pumice, the product being referred to as *verre-mousse*. The ancient glassmakers produced a sintered glass, for they had not enough heat at their disposal to melt the mix. Only when the glassmakers learned to generate enough heat did they produce glass. The same was true for porcelain. P. gives a brief review of glass blowing, leading up to the making of sintered glass filters of various grades and their many uses. M.Ho.

Progress made by glass proves ingenuity of industry in crisis. J. R. HAINER, JR. *Amer. Glass Rev.*, **63** [40] 17, 19, 55–56 (1944).—In the first year and a half of war the glass industry supplied replacements for critical materials, but in the second year and a half the emphasis has been on applications for actual combat conditions, life-saving, and other uses directly allied with the war program. H. describes contributions in optical glassware, the curved noses on B-29 bombers, mirrors for a variety of uses, fibrous glass for insulation and construction, foam glass, tableware for Army mess halls, food containers, and hospital glassware. A.P.

Properties and diagnosis of cords in pressed and blown glassware. L. G. GHERING AND M. A. KNIGHT. *Jour. Amer. Ceram. Soc.*, **27** [9] 260–66 (1944).—9 references, 1 figure.

Silicones to open new production fields. ANON. *Amer. Glass Rev.*, **63** [43] 10, 15 (1944).—Basic elements of silicones are sand, brine, coal, and oil. They can be produced either as solids or liquids in a variety of forms. Organosilicon oxide polymers, they are called a resin but have a different set of end properties. Developed for high temperature insulating coatings for glass fibers, they have been applied to improved motors and have also been used as compass liquids, for damping hydraulic fluids, for reducing the surface conductivity of ceramics, for antifoaming in lubricants, as packing in pumps handling hot liquids, and for secret military purposes. Postwar consumer uses are anticipated in household electrical appliances. A.P.

Thermal endurance of glass electric-lamp bulbs. S. M. KARIM, L. C. VERMAN, AND S. V. A. KRISHNAN. *Jour. Sci. & Ind. Research* [India], **2**, 92–101 (1944); *Brit. Chem. & Phys. Abs.–B*, **1944**, June, **I**, 200.—Thermal endurance of glass bulbs depends on the chemical composition, state of annealing, state of surface, shape, size, thickness of walls (0.3 to 0.8 mm.), and on the method of determination employed. The bulb to be tested is attached to a reflux condenser and placed in aqueous KNO_3-$NaNO_3$ (1:1); the temperature of the inside wall is kept at 100° (using H_2O), and temperature measurements are made with a Pt-Pt Rh thermocouple. The temperature of rupture is indicated by a sharp cracking sound. Thermal endurance of glass bulbs for the manufacture of first-grade lamps should be $\lessapprox$310°.

They live in a glass house and like it. ARTHUR W. BAUM. *Sat. Eve. Post*, **217** [8] 26–27, 39, 41 (1944); abstracted in *Bull. Amer. Ceram. Soc.*, **23** [9] 333–34 (1944).—The progress of the Corning Glass Works in the past 93 years is presented.

Time problem in annealing. ANIUTA WINTER. *Jour. Amer. Ceram. Soc.*, **27** [9] 266–74 (1944).—5 references, 11 figures.

PATENTS

Apparatus for handling mirrors during processing. R. W. WAMPLER (Libbey-Owens-Ford Glass Co.). U. S. 2,356,136, Aug. 22, 1944 (July 5, 1941).

Apparatus for scoring cover glass. N. H. KLAGES (American Window Glass Co.). U. S. 2,357,206, Aug. 29, 1944 (March 14, 1942).

Bending glass sheets. H. G. ORSER AND W. P. BAMFORD (Libbey-Owens-Ford Glass Co.). U. S. 2,357,537, Sept. 5, 1944 (Feb. 3, 1942).

Coating articles with glass. G. L. STRUBLER. U. S. 2,356,016, Aug. 15, 1944 (Oct. 8, 1941).—The method of coating articles with molten glass produced by heating glass particles in a heating zone which includes increasing the radiant heat available for melting the glass particles by burning a finely divided combustible solid material in the heating zone in the presence of the glass particles and creating an alkaline atmosphere in the heating zone at the same time for retarding extraction of alkali from the glass particles by introducing a finely divided solid alkaline material into the heating zone.

Glass enamel composition. C. J. HARBERT AND R. F. MORRISON (Harshaw Chemical Co.). U. S. 2,356,316, Aug. 22, 1944 (June 28, 1943).—A lead borosilicate glaze suitable for decorating glassware, having a fusing temperature not higher than 640°C. and exhibiting superior alkali resistance, the glaze comprising a pigment dispersed in a glaze matrix of lead borosilicate type and the matrix containing as smelted in addition for imparting high alkali resistance barium oxide and zirconium dioxide in the proportion of ZrO_2 41 to 67% and BaO 59 to 33% based on the combined weights of BaO and ZrO_2, barium oxide and zirconium dioxide aggregating 5 to 15% of the matrix by weight.

Glass enamel composition. C. J. HARBERT AND R. F. MORRISON (Harshaw Chemical Co.). U. S. 2,356,317, Aug. 22, 1944 (July 22, 1943).—A lead borosilicate glaze suitable for decorating glassware, having a fusing temperature not higher than 640°C. and exhibiting superior alkali resistance, the glaze comprising a pigment dispersed in a glaze matrix of lead borosilicate type and the matrix containing as smelted in addition for imparting high alkali resistance barium stannate in the proportion of 6 to 14% of the matrix by weight.

Glassforming machine. J. W. CARNAHAN (Hazel-Atlas Glass Co.). U. S. 2,357,501, Sept. 5, 1944 (Oct. 14, 1941).

Glass-grinding apparatus. G. R. ROESCH AND GERALD WHITE (Libbey-Owens-Ford Glass Co.). U. S. 2,356,-433, Aug. 22, 1944 (Aug. 12, 1941).

Jars and like containers and vacuum-sealed stoppers or closures therefor. ROCKWARE GLASS SYNDICATE, LTD., AND T. WARDLEY. Brit. 562,259, July 5, 1944 (Jan. 11, 1943).

Lens-grinding machine. PAUL WILHELM. U. S. 2,357,-154, Aug. 29, 1944 (April 17, 1943).

Lens and process for making. H. R. MOULTON (American Optical Co.). U. S. 2,357,345, Sept. 5, 1944 (Dec. 2, 1939).—The method of laminating a plurality of layers of

* From microfilm.

transparent material with one of the layers initially having a protective powder thereon.

Machine for beveling the edges of lenses. E. O. KOLLMORGEN. U. S. 2,356,488, Aug. 22, 1944 (June 30, 1942).

Machines for working tubular glass blanks. ELECTRO-LUMINATION, LTD., AND A. T. KEPHART. Brit. 562,327, July 12, 1944 (Feb. 2, 1943).

Making high-silica glass. M. E. NORDBERG AND H. E. RUMENAPP (Corning Glass Works). U. S. 2,355,-746, Aug. 15, 1944 (July 20, 1940; May 29, 1943).—The method of making a glass article which comprises melting a glass, fabricating it into a fixed shape, heat-treating the article to render constituents other than silica soluble, dissolving out major quantities of the other constituents to leave a highly siliceous, substantially transparent, porous article, impregnating at least a portion of the porous article with a solution containing a salt of a metal which will color glass and a compound of phosphorus, and drying and firing the article to close the pores and incorporate the metal into the glass.

Manufacture of blown-glass articles. H. F. TEICHMANN (Forter-Teichmann Co.). U. S. 2,357,702, Sept. 5, 1944 (Oct. 10, 1939).

Manufacturing felted mineral wool products. H. T. Coss, L. A. HAWTHORNE, AND J. H. ZETTEL (Johns-Manville Corp.). U. S. 2,357,042, Aug. 29, 1944 (April 24, 1941).

Manufacturing mineral wool and product. H. T. Coss, W. M. MACALPINE, AND L. A. HAWTHORNE (Johns-Manville Corp.). U. S. 2,356,826, Aug. 29, 1944 (May 24, 1940).

Method and apparatus for producing laminated glass. F. E. BARTELL. U. S. 2,355,696, Aug. 15, 1944 (Nov. 5, 1938).

Process and apparatus for the manufacture of laminated safety glass. O. H. PADDOCK (Libbey-Owens-Ford Glass Co.). U. S. 2,357,538, Sept. 5, 1944 (June 25, 1941).

Process to lower the reflection of optically active surfaces. G. J. WEISSENBERG (vested in the Alien Property Custodian). U. S. 2,356,553, Aug. 22, 1944 (Oct. 24, 1940).—A process of providing on a surface of a transparent article a thin, transparent layer of the character which affects the reflection of light incident on the surface comprising rendering the surface substantially clean and free of dirt, grease, and foreign substances, wetting the surface with an aqueous solution of an alkali silicate containing a compound selected from the group consisting of furfurol and dioxane, removing the excess wetting solution to leave a thin layer of wetting solution on the surface, drying the layer, reacting the layer with a stronger acid to precipitate silicic acid, washing the layer to remove reaction products other than silicic acid, and drying the layer to form a transparent silica coating of increased scratch resistance.

Structural Clay Products

Continuous plant for structural clay products. C. W. ISENHOUR, JR. *Bull. Amer. Ceram. Soc.*, **23** [9] 321–27 (1944).—6 figures.

Steam-hardened light brick of slag sands. F. KEIL AND F. GILLE. *Stahl & Eisen*, **63** [40] 735–36 (1943).—The compressive strength of a light lime-sandstone brick, which is made by a process of E. Hüttemann and W. Graf Czernin under the name Turrite, is up to 84 kg. per cm.^{2} for a density of 0.6 kg. per dm.^{3} and up to 260 kg. per cm.^{2} for a specific gravity of 1.4 kg. per dm.^{3}. The pores are so small as to be invisible under an ordinary microscope, and therefore the brick has a low heat conductivity. It can be nailed and sawed. It is made according to Ger. Pats. 626,576 and 635,559 of slaked lime with sand in the ratio 2:3, ground fine to a residue of about 20% on 4900-mesh. Of this powder, 500 kg. is mixed with 1000 liters of water and preheated in a boiler for about 3 hr. with superheated steam of 8 to 9 atm. abs. at 250° to 300°C. If the superheated steam is then suddenly released, a crumbly, sufficiently dry mass is produced, which is made leaner with 150 kg. volcanic rock or sand for each cubic meter, pressed in forms, and hardened and dried as usual in the lime-sandstone process. This process was also used for slag sands under steam hardening according to Ger. Pat. 716,736. The four slag sands used in the tests had the following composition:

	A	B	C	D
SiO_2	37.0	31.5	31.1	34.3
Al_2O_3	8.8	16.7	12.2	11.3
FeO	0.2	0.6	0.4	0.5
MnO	0.6	0.4	0.7	3.3
CaO	46.7	43.6	44.7	41.1
MgO	3.2	4.2	4.2	3.4
SO_3			0.2	
S	1.8	1.1	1.3	1.6
H_2O }	1.3	0.5	3.4	0.3
CO_2 }		Not calcd.	1.2	0.2
Residue on 4900 per cm.^{2} mesh (%)	20	20	10	About 2

A pure lime hydrate (Merck) that contained small amounts of unhydrated free calcium was used in making the brick. The fine-ground powder was mixed with 1.5 to 2 times as much water and preheated in an autoclave for 10 min. to 3 hr. at 10 atm. abs. in superheated steam. After the sudden release of the steam, the wet, crumbly mass was passed through a 576 per cm.^{2} mesh and then, alone or with additions of slag sand, precipitated SiO_2, trass, or the residue of a treatment of kaolin with sulfurous acid, put into forms. The humidity of the mass was such that under a pressure varying between 15 and 120 kg. per cm.^{2} small cylinders 25 cm. in diameter and 25 cm. high could be made which were then hardened in autoclaves at 9 atm. After cooling, some were stored in air, most were dried at 110°C., and all were tested. No pronounced differences were found between the heat- and air-dried specimens. The results of the tests can be summarized as follows: the least strength in relation to the weight per volume was found in the mixtures of slags and lime hydrate alone; specimens to which a material richer in SiO_2 than slag sand was added after the preliminary hardening gave better results, the best being obtained with precipitated SiO_2, with trass somewhat less. The most favorable ratio of compressive strength to weight per volume was found in the mixtures made according to Ger. Pat. 716,736 of lime hydrate and ground quartz sand instead of slag sand. A preliminary treatment of the slag sand-limewater mixture by leaving it for 10 days at room temperature or by evaporating the water does not replace even a short steam treatment. The most favorable mixture is 100 parts of slag-sand powder, 14 parts lime hydrate, and 12 parts SiO_2-rich addition; a short pretreatment of only 0.5 to 1.5 hr. is required instead of 3 hr. as with slag sand alone, but the ratio of compressive strength to weight is somewhat lower. A difference between ordinary basic blast-furnace slags exists only inasmuch as the slags which are heavier due to their higher Mn content (sand D) give also a heavier brick. Alumina-rich and alumina-poor slag sands behaved differently, depending on test conditions. It can be assumed that pumice powder, kieselguhr, and the residue of a treatment of kaolin behave as favorably as SiO_2. M.HA.

Modular masonry. H. C. PLUMMER. *Jour. Can. Ceram. Soc.*, **13** (Part 2), 1–8 (1944).—P. reviews the background and the progress of the movement for modular planning, the proposed modular sizes for brick and tile, and the probable effect of modular planning upon the brick and tile industry. He concludes that modular design will reduce masonry cost, putting the industry in a more favorable competitive position; that the elimination

of cutting and patching will contribute to better masonry; and that interest on the part of architects, engineers, and designers in masonry construction will be renewed. See *Jour. Amer. Ceram. Soc.*, **26** [9] 307–20 (1943).
G.A.K.

PATENTS

Brick, building block, etc. R. G. TARRAN. Brit. 562,154, July 5, 1944 (March 12, 1943).

Building construction. E. M. WALSH. U. S. 2,357,367, Sept. 5, 1944 (Oct. 29, 1941).—In a wall construction, in combination with a plurality of masonry backing blocks laid up in tiers having horizontally disposed cementitious joints therebetween, a facing therefor composed of a plurality of laterally adjacent vertically overlapping facing units, each facing unit including a rearwardly extending tongue anchored in the horizontal cementitious joints between the backing blocks, and a flashing strip disposed behind the joints between adjacent facing units, each flashing strip including a rearwardly extending tongue anchored in the horizontal cementitious joints between backing blocks below the tongue of the facing units.

Manufacture of brick, tile, etc. S. F. LITCHFIELD. Brit. 562,133, July 5, 1944 (Nov. 12, 1942).

Refractories

Basic refractories for the copper industry: II. R. P. HEUER AND A. E. FITZGERALD. *Metals & Alloys*, **19** [6] 1405–1407 (1944).—The refractories in the tuyère section or back of basic copper converters provide the greatest maintenance requirements, being exposed to a maximum of abrasion, slag attack, thermal and mechanical shock, and structural strain. Either special shapes or a granular refractory material is used around the tuyère pipe. Brick construction using the special shapes is described. Magnesite brick, being highly resistant to iron and copper oxides and being able to hold a protective coating of magnetite, are generally used. Chrome-magnesite brick show no advantage over magnesite, except that the unburned type is more economical owing to its initial lower cost; a similar situation exists in operations handling matte and scrap where no protecting magnetite coating forms. Methods of setting refractories in converters in evaluating various types are discussed. For Part I see *Ceram. Abs.*, **23** [7] 124 (1944). B.C.R.

Beryllium oxide. L. DAVID. *Metallurgia*, **30** [176] 91–93 (1944).—Above 1400°C., beryllium oxide has a higher strength than Al_2O_3, ZrO_2, ThO_2, or synthetic $MgO \cdot Al_2O_3$. The highest working temperature for beryllia ware is about 2400°C. Ceramic products of beryllium oxide can be made gastight at 2200°C. They resist molten alkalis and do not react with carbon, carbon monoxide, or hydrogen, but they are very susceptible to acid attack. The procedure of manufacturing crucibles and refractory forms is described, as well as the extraction of beryllium from raw beryl. 14 references. E.C.P.

Glost-kiln refractories. EDWARD SCHRAMM. *Jour. Amer. Ceram. Soc.*, **27** [9] 282–84 (1944).—3 figures.

Open-hearth furnace refractories. KENNETH ROSE. *Metals & Alloys*, **19** [4] 885 (1944).—Properties of various refractories used in open hearths are discussed. Temperatures, load, and service effects for each part of the furnace are given. B.C.R.

Open-hearth refractory and masonry problems discussed at conference. ANON. *Ind. Heating*, **11** [7] 1144–52; [8] 1320–26 (1944).—The topics under discussion at the annual conference of the National Open Hearth Committee of the American Institute of Mining and Metallurgical Engineers in Pittsburgh, April, 1944, included the life of refractories, new developments in refractories (especially basic types), new construction methods, water-cooling, drop sections, roof thickness, basic front walls and bulkheads, regenerators, and special refractories such as mullite and silicon carbide brick in open-hearth furnace roof construction. A discussion of maintenance practices concluded the session. M.HA.

Pure oxide refractories. D. KIRBY. *Metallurgia*, **30** [176] 65–69 (1944).—The applications and properties of fused alumina, recrystallized alumina, beryllia, magnesia, thoria, zircon, zirconia, and spinel are considered briefly. E.C.P.

Silica refractory flat arch saves 20% fuel. ANON. *Brick & Clay Record*, **105** [1] 39–40 (1944); *Ceram. Ind.*, **43** [2] 53 (1944).—Demands for closer heating control have led to tighter furnace construction. Suspended arches using fully offset tile minimize air infiltration or gas leakage through the roof. The application of this type of construction to continuous glass tanks has resulted in appreciable fuel savings. B.C.R. & H.T.

Silicon carbide brick as refractory material. H. KALPERS. *Glashütte*, **73**, 111–12 (1943); abstracted in *Chem. Zentr.*, **1943, II** [13] 1219.—The use of silicon carbide brick is recommended because of its high heat conductivity, great mechanical strength, and resistance to high temperatures and to attack by ash and slag. M.HA.

Substitution of topaz, domestic kyanite, and synthetic mullite-corundum for India kyanite: IV, Raw topaz as high-temperature bond for domestic kyanite. T. N. MCVAY, W. W. GALBREATH, JR., AND DAN ALLEN. *Jour. Amer. Ceram. Soc.*, **27** [9] 275–82 (1944).—2 references, 13 figures. For Parts **I–III** see *ibid.*, **26** [8] 252–66 (1943); see also *ibid.*, **27** [8] 241–46 (1944).

Symposium on significance of tests on refractories: Value of tests on refractories. STUART M. PHELPS. *Bull. Amer. Ceram. Soc.*, **23** [9] 310–15 (1944).—2 references. **Testing refractories from the standpoint of research.** FRED A. HARVEY. *Ibid.*, pp. 315–17.—7 references. **Significance of a steel-plant refractories testing program.** W. S. DEBENHAM. *Ibid.*, pp. 317–20.—7 references, 1 figure.

PATENTS

Dissolving raw aluminates of lime in water and recovering alumina from such solutions. J. C. SÉAILLES (vested in the Alien Property Custodian). U. S. 2,356,626, Aug. 22, 1944 (March 12, 1940).—(1) In dissolving raw calcium aluminate to form a stable solution, the method which comprises extracting the raw aluminate with an aqueous solution of an ionizable alkaline compound chosen from the group consisting of hydroxides and carbonates of the alkali metals, the solution of the alkali used having not in excess of 1 mol. for 1 mol. of alumina in the extracted aluminate, the solution being used in the proportion of at least 1000 parts to 5 parts of dissolved aluminate. (3) In the preparation of an aluminate solution, the method which comprises extracting raw aluminate with an aqueous solution including an alkaline compound of an alkali metal selected from the group consisting of hydroxides and carbonates of the alkali metals and an alkali-metal sulfide, the sulfide retarding solution of silica.

Process for the manufacture of alumina (metallurgical grade) from highly siliceous aluminous ores. GANT GAITHER. U. S. 2,356,157, Aug. 22, 1944 (Feb. 3, 1942).—A process for extracting alumina from iron-containing alumina ores which comprises digesting the ore in hydrochloric acid to produce a solution of aluminum and iron chlorides, separating the solution from any undissolved residue, adding ammonium acid sulfate to the solution and heating to drive off hydrochloric acid which is recovered and reused in digesting more ore, and obtaining a residual solution of mixed sulfates of aluminum, iron, and ammonium, crystallizing ammonium alum from the solution, purifying the ammonium alum to the desired degree by recrystallization, dissolving the recrystallized ammonium alum, precipitating aluminum hydroxide therefrom by introducing ammonia, separating the alumi-

num hydroxide product from the solution, collecting this solution and the mother liquor from the crystallization of alum and precipitating iron therefrom, leaving a solution containing ammonium sulfate, and heating the solution to recover ammonium acid sulfate and ammonia therefrom for re-use in the process.

Whiteware

Onondaga Pottery Co. aids U. S. by producing nonmetallic mines. ANON. *Bull. Amer. Ceram. Soc.*, **23** [9] 331 (1944).—A nonmetallic high-explosive land mine that cannot be detected by the enemy's electrical mine detectors is being produced in the Rochester Ordnance District. 2 photos.

SEPARATE PUBLICATIONS

Final Report on Shrinkage Control of Steatite Porcelain for Radio and Radar Equipment: I, Methods of Controlling Firing Shrinkage of Dry-Pressed Steatite Bodies. R. L. STONE. *War Production Board*—46, *Office of Production Research and Development*—226, Jan. 2, 1944. 45 pp.—This research was concerned principally with determining the factors that can cause the firing shrinkage of steatite bodies to vary in consecutive batches and with consecutive shipments of raw materials. The following factors were studied: (1) methods of dry-mixing the body constituents, (2) particle-size analyses of the talcs, (3) substitution of certain body constituents without changing the ultimate analysis of the body, and (4) control of the manufacturing procedure. Results show that the most satisfactory mixing procedure is to mix the dry constituents in a ribbon-type mixer followed by processing through a high-speed hammer mill. This mixing procedure eliminates much of the variation in shrinkage and produces excellent surfaces on the fired product. Variations of the particle-size analyses of the talc within the limits of commercial grinding do not affect the firing shrinkage of the body if a constant dry bulk specific gravity of the pressed body is maintained. In automatic presses the die fill is constant; therefore, bulk density of the granules of the body must be held constant by controlling the following: (1) the percentage of water used in wet-mixing the body, the maximum bulk density for a body being obtained by using an amount of water that will produce a stiff-mud consistency; (2) the water content of the body at the time of granulation, the maximum bulk density and the minimum amount of fines being obtained when the mass contains the maximum content that can be used without causing clogging of the granulator screens; and (3) the sieve analyses of the granules, the bulk density decreasing as the amount of fines (-65 or -100 mesh) is increased regardless of how the fines are produced. Composite firing curves are given for several bodies, which show the relationship of dry-pressed bulk specific gravity (combustible free basis) and firing temperature to volume shrinkage and fired bulk specific gravity. The composite curves consist essentially of a series of dry-pressed bulk specific gravity lines, each line being the loci of points representing the relationship of a given dry bulk specific gravity, calculated on the combustible free basis, to the fired bulk specific gravity and volume firing shrinkage of steatite specimens having that dry bulk specific gravity. These curves show that for $BaCO_3$-clay-talc bodies an increase in the dry-pressed bulk specific gravity (by increasing the forming pressure) decreases both the volume firing shrinkage and the fired specific gravity. For feldspar-talc bodies the fired specific gravity is increased. The curves of constant dry-pressed bulk specific gravity are sloping lines, indicating that an increase in fired bulk specific gravity of thoroughly vitreous bodies is accompanied by an increase in volume shrinkage. Results show that some talcs produce higher fired bulk specific gravities than other talcs and therefore produce greater firing shrinkage even though bodies containing each talc are pressed to the same dry-pressed bulk specific gravity (combustible free basis). This is the explanation for shrinkage variations in consecutive shipments of talc, but the error in shrinkage can be corrected by adjusting the forming pressure. 7 figures, 7 tables. **Supplement I to Part I, Effects of Storage Conditions on the Shrinkage of Dry-Pressed Steatite Bodies.** *Ibid.*, June 7, 1944. 18 pp.—Dry-pressed steatite bodies expand very rapidly for a few seconds after release of the forming pressure and then continue to expand for at least 6 days when the pieces are stored at temperatures up to 90°F. The effects of various storage conditions on the rate of expansion and on the firing shrinkage of dry-pressed steatite bodies were investigated. The results indicate that the interval the pressed pieces are stored before firing does not affect the firing shrinkage in any way when the calculated shrinkage values are based on (1) either the die diameter or the specimen diameter 2 min. after ejection and (2) the thickness of the pressed piece 2.5 min. ± 30 sec. after ejection from the die. The pressed bodies expand so rapidly for the first 2 min. after ejection that measurements made during that period are not sufficiently reliable for use in calculating bulk specific gravity data. The expansion can be stabilized by storing for 2 hr. at 140°F. or 1 hr. at 220°F.; it is advisable, therefore, to so stabilize bodies used for drilling and tapping because drill and tap sizes are based on shrinkage of the body at the time the operations are performed. Some steatite bodies expand as much as 5.0% by volume, and this can cause appreciable error in tapped holes. Results show that the final expansion (stabilized either by heating or by storage for a long interval at 90°F.) is greater in the direction of pressure application than at right angles to it. 2 figures, 4 tables. **II, Investigation of Binders, Lubricants, and Plasticizers for Dry-Pressed Steatite Bodies.** *Ibid.*, May 1, 1944. 71 pp.—The purpose of this research was to develop binder-lubricant combinations having characteristics superior to those of the combinations previously used by the industry for producing simple shapes. The granules used for pressing contained no moisture. The following are the prerequisites of a satisfactory binder-lubricant combination: (1) The lubricant must produce absolute freedom from sticking to the punch faces, die walls, and core pins over the temperature range 70° to 100°F. and a relative humidity of 60.0 to 70.0%. (2) The body must have sufficient flow under pressure so that complex shapes having uniform density throughout can be formed without employing excessively high forming pressures. (3) The binder must have sufficient adhesiveness to produce high mechanical strength in the pressed pieces at feasibly low forming pressures. (4) The binder must impart plastic strength to the body at the mixer to facilitate granulating. (5) The body must be sufficiently "tough" to prevent the formation of dust in handling the dry granules. (6) The granules of the body must be sufficiently soft so that an excessively high forming pressure is not required to produce a smooth surface. (7) The binders, lubricants, and plasticizers, if of the organic type, must be of such a nature that they can be completely and easily eliminated from the body by oxidation or distillation (they must not be detrimental to the electrical properties of the dielectric if they are of the inorganic type). (8) The granules of the body must be of such a nature that they will permit removal of air from the die cavity when the pieces are being formed. The types of binders investigated included typical starches, dextrines, and glucoses derived from yellow potato, white potato, tapioca, rice, corn, and wheat; natural gums; lignin extracts; resins; pitches and asphalts; polyvinyl alcohol; waxes; etc. Stearic acid and many fatty-acid derivatives, cetyl alcohol, hydrogenated vegetable oils, liquid fatty acids, petroleum oils, and many petroleum waxes were investigated as lubricants. A low-clay barium carbonate body was used, and 3.0% of the various binders was incorporated. The water-soluble powdered binders were added as powders to the dry body constituents, and the

whole was processed through a high-speed hammer mill. The waxes, when used as binders, and binders purchased in liquid form were added as emulsions to the body in the muller-type mixer. The lubricants were incorporated by several methods: (1) as powders and processed with the other body constituents through a high-speed hammer mill; (2) as powders added to dry granules of the body prior to pressing; (3) as emulsions added to the plastic mass in a muller-type mixer; and (4) as liquids and emulsions sprayed on the dry granules of the body prior to pressing. Methods 1 and 3 were more effective in increasing flow of the body under pressure, while methods 2 and 4 were more effective in preventing sticking and galling. Zinc stearate and magnesium stearate were found to be more effective than stearic acid in preventing sticking and galling. The incorporation of all the lubricants (particularly the oils) decreased the mechanical strength of the pressed specimens. The following test was devised for determining the flow-under-pressure characteristics of steatite bodies: A 1-in. diameter specimen of the body was pressed at 30,000 lb. per sq. in. One of the punches was then replaced by a similar punch in which a 0.125-in. hole was drilled. The pressure necessary to cause flow through the hole was recorded. A combination of two or more binders was necessary to obtain satisfactory properties, e.g., 1.0 to 3.0% of a nonwax binder such as gum ghatti, gum arabic, or Flocgel was added to provide plastic strength in the muller mixer, and 2.0 to 3.0% of Cerese Wax AA or similar high melting point wax was added to provide mechanical strength of the pressed parts. The nonwax binders (such as the gums) were added as powders and processed with the body through a high-speed hammer mill, and the waxes were added as emulsions at the muller-type mixer. Powdered zinc stearate (1.0%) was added to the dry granules of the body to prevent galling. All bodies containing only waxes were sensitive to humidity conditions of the atmosphere and showed sticking with a relative humidity of 60% or higher. Bodies containing the nonwax binders with stearic acid as the lubricant were less sensitive to high humidity. 11 figures, 12 tables. **Supplement I to Part II, Effects of Bulk Specific Gravity on the Electrical and Mechanical Properties of Dry-Pressed Steatite.** *Ibid.*, June 21, 1944. 12 pp.—The object of this investigation was to determine the relationship of the pressed bulk specific gravity, calculated on a combustible free basis, of dry-pressed steatite products to the electrical and mechanical properties after firing. The pressed bulk specific gravity has very little effect on the electrical properties, but the modulus of rupture of the vitrified product increases in direct proportion to the unfired bulk specific gravity. The investigation also covered a study of the relationship between surface texture of the vitrified product and the electrical properties. The results show that surface texture has little effect. 1 figure, 2 tables. **Supplement II to Part II, Investigation of Binder Combinations for Dry-Pressed Steatite Parts of Complex Shape.** *Ibid.*, Aug. 1, 1944. 63 pp.—The objects of this investigation were (1) to develop binder combinations that would produce bodies having the following forming properties, (*a*) the pressed bulk specific gravity vs. forming pressure curves must be reasonably flat in the range 10,000 to 16,000 lb. per sq. in., thereby permitting the use of a wide range of forming pressures without affecting the bulk specific gravity of the pressed pieces; (*b*) the flow pressure, as determined by the test described in Part II, p. 45, must not exceed 18,000 lb. per sq. in., and (2) to develop a system of shrinkage control which can be used with these binder combinations. Bodies containing 9.0% of a wide variety of wax and waxlike substances were investigated. Most petroleum waxes caused the bodies to stick to the punches, but three waxlike materials (Sterotex, Stonex, and cetyl alcohol) were found which produced absolute freedom from sticking. Bodies containing 5.0 to 8.0% of these waxlike materials were investigated, and excellent results were obtained. An improved system of shrinkage control and the test procedure to be used were developed. The steps in the system of control are basically as follows: (1) prepare the production batch by standard procedures; (2) determine the percentage of combustibles present and the dry-pressed bulk specific gravity (combustible free basis) of the body formed at 16,000 lb. per sq. in.; (3) from production charts and records of the body being tested, determine what the firing shrinkage of the body as prepared would be; and (4) from production charts and records of the body being tested, determine the percentage of "shrinkage-control agents" to be added to the granules of the body to bring the shrinkage up to specified values. Combinations of binders and shrinkage-control agents are given for producing both simple and complex shapes. The following conclusions are given: (1) Percentages of wax in steatite bodies in excess of 7.0 to 8.0% cause trouble from blistering, fish-scaling, and sticking to punch faces. (2) The compressibility ratio of steatite bodies is proportional to the amount of mixing water required to produce a standard degree of workability. Bodies requiring high percentages of mixing water have high compressibility ratios. (3) Bodies having very low expansion after ejection show greater tendencies to blister and fish-scale than those having higher expansions. (4) The incorporation of 1.0 to 2.0% Flocgel or similar starch binders to steatite bodies containing wax (*a*) decreases the amount of mixing water necessary to produce the desired workability, (*b*) increases the plastic strength of the body, (*c*) decreases the tendency of bodies to stick to the punch faces, blister, and fish-scale, (*d*) decreases the compressibility ratio, (*e*) decreases the dry bulk specific gravity, combustible free basis, (*f*) increases the volume firing shrinkage, (*g*) increases the forming pressure required to "level out" the pressure-specific gravity curve, and (*h*) increases the expansion after ejection. (5) If the granules of bodies containing wax binders are dried at 120° to 140°F., preheating them in a tumbler-type mixer to 180° to 200°F. before pressing (*a*) tends to eliminate the fines by agglomeration, (*b*) decreases the tendency of the body to stick to the punch faces, (*c*) decreases the expansion after ejection, (*d*) increases the green bulk specific gravity of the pressed specimens, (*e*) decreases the flow pressure, (*f*) increases the mechanical strength of the pressed specimens, and (*g*) increases the tendency of the body to blister and fish-scale. (6) An increase in the wax content of the bodies (*a*) increases the amount of mixing water required to produce the desired workability of the body, (*b*) increases the tendency of the body to stick to the punch faces, (*c*) decreases the expansion after ejection of the body, (*d*) decreases the dry bulk specific gravity, combustible free basis, (*e*) increases the firing shrinkage, and (*f*) increases difficulties arising during firing. (7) The volume (and diametral) shrinkage can be controllably increased by adding shrinkage-control agents to dry granules of the body. (8) The incorporation of shrinkage-control agents followed by heating the granules to 180° to 200°F. (*a*) decreases the tendency of the bodies to stick to the punch faces, (*b*) decreases the dry (unfired) bulk specific gravity, combustible free basis, (*c*) increases the volume firing shrinkage, and (*d*) increases the tendencies of bodies to blister, laminate, and fish-scale. (9) The most satisfactory binders are Stonex (a patented blend of waxes), Sterotex (a hydrogenated vegetable oil), Ouricury wax, and cetyl alcohol. (10) The most satisfactory shrinkage-control agents are (*a*) powdered (200-mesh) Ouricury wax, especially for use with petroleum-wax binders; (*b*) stearic acid (and stearates), satisfactory with petroleum-wax bodies only where heated punches and dies are employed; and (*c*) stearic acid (and stearates) for use in bodies containing Stonex, cetyl alcohol, and Sterotex as binders. 14 figures, 10 tables. See "Ceramic. . . ," *Ceram. Abs.*, **23** [9] 154 (1944). R.L.S.

PATENTS

Design for pottery mold caster's bench. L. P. REESE. U. S. 138,575, Aug. 22, 1944 (Sept. 14, 1943).

Handle for cups and like receptacles. S. REED. Brit. 562,227, July 5, 1944 (April 1, 1943).

Increasing the retention capacity of the sealing surface of artificial porcelain teeth. P. J. J. GONON (vested

in the Alien Property Custodian). U. S. 2,356,513, Aug. 22, 1944 (March 3, 1942).—A process for increasing the retention capacity of the sealing surface of artificial porcelain teeth which comprises coating the sealing surface of the tooth with a mixture of a substance having an adhesive capacity at ordinary temperatures and of a ceramic material having a fusing point inferior to that of the tooth porcelain, sprinkling elongated particles of alumina on the coated surface, the particles having a particle size between 300 and 720 microns, orienting the particles so that they are held by their most narrow base upon the coated surface and extend substantially outwardly therefrom, and then subjecting the tooth to a firing operation.

Insulator. D. H. Rowland and C. D. Croskey (Locke Insulator Corp.). U. S. 2,357,550, Sept. 5, 1944 (June 16, 1941).—The method of forming a metallized surface on ceramic bodies which comprises applying to the ceramic body, prior to firing, a glaze composition having a coefficient of expansion in the nature of 4.0×10^{-6} per °C., the glaze composition incorporating between 5 and 8% calcium carbonate by weight, allowing the glaze to dry, applying to a selected portion of the glaze a dilute solution of hydrochloric acid to form in the glaze surface a plurality of undercut craters, subsequently firing the coated ceramic body, and finally applying to the treated portion a metallic coating by the spray method.

Method and apparatus for feeding plastic clay to molds in the manufacture of pottery ware. G. J. Croninger (Miller Pottery Engineering Co.). U. S. 2,356,829, Aug. 29, 1944 (March 10, 1944).

Spark plug. A. C. Hastings, Jr., O. B. Hastings, and W. R. Horsfield. U. S. 2,356,053, Aug. 15, 1944 (May 14, 1941). M. F. Peters and F. I. McCarthy. U. S. 2,357,602, Sept. 5, 1944 (June 5, 1942).

Spark plug and method of making. Tullio Tognola (Bendix Aviation Corp.). U. S. 2,356,104, Aug. 15, 1944 (Oct. 11, 1941).

Equipment and Apparatus

Bibliography of electron microscopy. Claire Marton and S. Sass. *Jour. Applied Physics*, **14** [10] 522–31 (1943).—To celebrate the tenth anniversary of the development of electron microscopy, a bibliography has been assembled containing the scientific papers in the following categories: (1) books, (2) emission microscopy, (3) transmission-type microscope, (4) optics of the transmission-type electron microscope, (5) image defects, (6) electron speeds above 100 kv., (7) different related instruments, and (8) applications of the transmission-type microscope. A.P.

Compact high resolving power electron microscope. V. K. Zworykin and James Hillier. *Jour. Applied Physics*, **14** [12] 658–73 (1943).—Electron microscopes have now reached a stage where simplicity and refinement are stressed in the design. Considerations controlling design are discussed, construction details are analyzed, and a few electron micrographs are reproduced. A.P.

Compilation of papers published by Moritz von Rohr. K. Jahn-Jubelt. *Forsch. Geschichte Optik*, **3** [3] 115–36 (1943).—A complete list of the 568 papers (of which 31 were written in cooperation with others) on optical and physiological subjects is presented. M.Ha.

Conveying by compressed air. Anon. *Mech. Handling*, **31** [5] 198–201 (1944).—A method of conveying such materials as cement, coal, chemicals, grains, scrap, etc., by the use of compressed air is described. 1 diagram, 4 photographs. M.R.

Cyclotron. M. Stanley Livingston. *Jour. Applied Physics*, **15** [1] 2–19; [2] 128–47 (1943).—The cyclotron is undergoing a transition from an academic luxury to an indispensable tool for applied science and industry. Its use as a production unit may even outweigh its further scientific usefulness. L. comprehensively evaluates information which may aid in improving the efficiency, reliability, and output and in determining the most economical sizes and designs of cyclotrons for large-scale applications. A.P.

Dioptrics of electron-optical instruments with any curvature of the axes of reproduction. G. Wendt. *Z. Physik*, **120** [11/12] 720–40 (1943).—W. presents the derivation of a complete theory of electron-optical instruments with curved optical axes, which deals with that orbit of electrons connecting the center of the plane of the object with the center of the plane of the picture. Calculations of focal lengths and principal planes are given. M.Ha.

Distillation process control is aided by new Corning-made apparatus. Anon. *Amer. Glass Rev.*, **63** [42] 18 (1944).—The Corad still head permits greater control of distillation processes and has been particularly useful in laboratory work on synthetic rubber. The name is derived from the description, "*co*nstant reflux *ra*tio hea*d*." A.P.

Drying of raw and worked clay by means of infrared rays. M. Déribéré. *Usine*, **52** [22] 9 (1943); abstracted in *Chem. Zentr.*, **1943, II** [13] 1219.—The possibilities of economical drying processes for clay and clay products using infrared lamps are discussed. M.Ha.

Early history of the electron microscope. R. Rüdenberg. *Jour. Applied Physics*, **14** [8] 434–36 (1943).—R. tells how he happened to invent the electron microscope in 1930 as established by U. S. Pats. 2,058,914 and 2,070,319. A.P.

Electron microscopic determination of surface elevations and orientations. R. D. Heidenreich and L. A. Matheson. *Jour. Applied Physics*, **15** [5] 423–35 (1944).—The methods of determining object thickness in electron microscopy are (1) determination of intensities on photographic plates, (2) random orientations, and (3) stereoscopy. The last is superior for the study of surface replicas and of particles. The stereo technique is analyzed. Devices for studying aerial maps and a new cartridge specimen holder were utilized. The thickness of kaolin clay crystals averaged 150 ± 50 a.u. Elevation changes of 200 a.u. and less can be measured in silica replicas of polished surfaces. A.P.

Electron microscopical fine structures in glass fractures. E. Gölz. *Z. Physik*, **120** [11/12] 773–77 (1943).—Rough spots which form on fractured areas of glass rods mainly as a transition zone between the "mirror" and the "grooved plane" are investigated with the electron microscope. The increase in fineness of the individual grooves or fissures progresses toward the side of the mirror in the range of the ultra-light microscope. Transition zones between "smooth" and "rough" ranges in electron-microscopic pictures lead to the conclusion that even below the limits at present obtainable with the electron microscope, still finer fissures exist. Reproductions of transition areas at a magnification of 6000× are included. M.Ha.

Frictional phenomena: XV, External friction of solids. A. Gemant. *Jour. Applied Physics*, **14** [9] 456–64 (1943).—The fundamental mechanism of external friction between sliding solids is dependent on pressure, speed, and temperature and is complicated by plastic deformation of the surface, irregularities, and abrasion. Experimental data on coefficients of friction for various materials include glass to glass 0.40, carbon to glass 0.18, and ebonite to glass 0.53. **XVI, Technical applications of external friction of solids.** *Ibid.*, [10] 510–21.—G. describes technical applications of friction to belt drives, clutches, brake-vibration dampers, shaft whipping, and grinding and crushing. For Parts **XIII** and **XIV** see *Ceram. Abs.*, **23** [1] 25 (1944). A.P.

Magnification calibration of the electron microscope. E. F. Fullam. *Jour. Applied Physics*, **14** [12] 677–83 (1943).—A method proposed for calibrating the magnification of the electron microscope compensates for the errors

due to mechanical and electrical variations of the instrument by mounting microscopic glass spheres of predetermined size directly on the specimen-supporting film. The spheres are graded by controlled levigation and calibrated internally on a grating replica at a low magnification with a low electron-beam intensity. The spheres are placed on the film by evaporation from a water suspension. Accuracy is estimated to be about ±3%. A.P.

Mechanized furnaces. W. HIND. *Mech. Handling*, **31** [5] 216–19 (1944).—H. discusses furnaces provided with mechanical handling equipment for mass-production operation. The furnaces described are used mainly for annealing, heat-treatment, and stress relieving. 4 photographs. M.R.

Modern spectrochemical analysis. E. K. JAYCOX. *Jour. Applied Physics*, **14** [12] 619–31 (1943).—J. discusses applications of the spectrograph to the analytical problems of research and industrial organizations. A.P.

New contributions to interferometry: III, Differential polarization phase change on reflection at a thin silver mirror. S. TOLANSKY. *Phil. Mag.*, **35** [242] 179–87 (1944).—Reflection polarization for a thin (0.1 wave length) silver film was determined for green mercury light. A multiple-beam Newton ring apparatus was used to measure the differential effect over a range of 0° to 80°. Results are compared with theory and found to agree for angles up to 60°. Beyond 60° the existing theoretical treatment was found inadequate. Application to the Fabry-Perot interferometer is discussed. **IV, Ghost images and scatter rings of the Fabry-Perot interferometer and their effects on hyperfine structure observation.** *Ibid.*, [243] 229–41.—Analysis is made of secondary images and the scattering of light in the interferometer as they relate to spectroscopy. For Parts I and II see *Ceram. Abs.*, **23** [9] 156 (1944). S.Z.

pH measurements on thixotropic gel systems using the glass electrode. R. C. VOGEL AND M. W. LISSE. *Jour. Phys. Chem.*, **47**, 678–85 (1943).—pH measurements using a glass electrode were made on thorium molybdate, ferric hydroxide, and bentonite gel systems. Readings were taken throughout the process of primary gelation, thixotropic liquefaction by shaking, and subsequent secondary gelation. During the primary gelation, the pH of the thorium molybdate system increased from 2.57 to 2.62, and that of the ferric hydroxide system decreased from 4.50 to 4.40. The pH of the bentonite system remained constant at 4.87. There was no change in any of the three systems during the process of thixotropic liquefaction or in the subsequent regelation. R.A.G.

Physical procedures used in ceramic research. G. A. BOLE AND G. A. LOOMIS. *Jour. Applied Physics*, **14** [9] 443–50 (1943).—The applications of physical apparatus and procedures to ceramic research at the Engineering Experiment Station of Ohio State University include (1) thermal-expansion determination by dilatometer or interferometer, (2) glaze-fit measurement by fork-shaped or ring test pieces, (3) determination of sonic properties of structural clay tile as a means of predicting failure by measurement of the modulus of elasticity or of "damping" from the log decrement of vibration, (4) determination of the sonic properties of glass as affected by variations in composition, in annealing, and in dimensions, (5) electron-microscope studies of surface replicas as a means of measuring the scratch hardness of glazes, (6) cyclotron bombardment as a method for measuring the thickness of a gold band on dinnerware, and (7) ultrasonic vibration to increase the dispersion of clay in water. A.P.

PATENTS

Apparatus for shaping articles. FRANK MARTINDELL (Western Electric Co.). U. S. 2,355,812, Aug. 15, 1944 (July 23, 1943).

Chlorination of chromium-bearing materials. F. J. CLEVELAND (Pittsburgh Plate Glass Co.). Brit. 562,163, July 5, 1944 (Jan. 27, 1942).

Insulator-cutting machine. E. M. SKIPPER (Locke Insulator Corp.). U. S. 2,355,684, Aug. 15, 1944 (July 31, 1941).

Mechanism for extruding moist clay, etc. S. C. LYONS AND D. H. YOUNG (Georgia Kaolin Co.). U. S. 2,356,862, Aug. 29, 1944 (Jan. 24, 1942).

Method and apparatus for the production of ceramic shaped bodies, especially clay tile. WILHELM AVENHAUS (vested in the Alien Property Custodian). U. S. 2,356,496, Aug. 22, 1944 (Sept. 24, 1940).—Apparatus for the manufacture of prismatic ceramic bodies comprising means for periodically downwardly discharging clay in the form of a column of predetermined length, means for subdividing the formed column both parallel to and also at right angles to the direction of discharge, underlying means for supporting the column during subdivision, and means for moving the supporting means downwardly and laterally upon completion of the severing, whereby to remove the severed portion of the column from the remainder thereof and to displace the portion to make room for another column.

Method of and apparatus for shaping articles. FRANK MARTINDELL (Western Electric Co.). U. S. 2,355,811, Aug. 15, 1944 (July 23, 1943).

Mixing apparatus for crystalline and finely divided substances. PASCALL ENGINEERING CO., LTD., AND G. B. STRINGER. Brit. 562,431, July 12, 1944 (March 15, 1943).

Radiation pyrometer. FOSTER INSTRUMENT CO., LTD., AND J. T. DAVIES. Brit. 562,135, July 5, 1944 (Nov. 17, 1942). T. R. HARRISON (Brown Instrument Co.). U. S. 2,357,193, Aug. 29, 1944 (Sept. 24, 1941).

Tile-cutting machine. W. A. HISLOP. U. S. 2,356,406, Aug. 22, 1944 (March 9, 1942).

Kilns, Furnaces, Fuels, and Combustion

Automatic coal scales aid fuel saving. T. W. REYNOLDS. *Heating & Ventilating*, **41** [7] 84 (1944).—B. discusses the use of automatic scales in providing accurate boiler-room information. This in turn permits proper accounting. M.R.

Designing stokers so that they will burn available low-grade fuels. C. HALLMAN. *Heating & Ventilating*, **41** [7] 77–78 (1944).—Practically every type of commercial fuel can be burned satisfactorily on an underfeed stoker if sufficient live grate area is provided to suit the requirements of the particular coal to be burned. H. recommends that the interests of users, manufacturers, and fuel producers would be served best if ratings for single-retort underfeed stokers be set up for the coal-burning capacity rather than the coal-feeding capacity. 2 diagrams. M.R.

Improvements and future plans for tunnel kilns. JOHN H. ISENHOUR. *Bull. Amer. Ceram. Soc.*, **23** [9] 327–29 (1944).

Use of gas in processing the materials of tomorrow. L. E. BIEMILLER. *Steel Processing*, **30** [6] 375–78 (1944).—B. discusses the use of gas in the steel, plastics, glass, ceramic, and aluminum industries. He points out the effect of insulating refractories and convection, furnaceless, immersion, and radiant-tube heating on such use. M.R.

PATENTS

Control device for furnaces. M. Z. VON MANTEUFFEL (vested in the Alien Property Custodian). U. S. 2,356,135, Aug. 22, 1944 (Dec. 11, 1940).—In a device for controlling the fuel feed and the supply of combustion air to a furnace, the combination comprising fuel-feed means and air-supply means.

Traveling grate for stokers. R. L. BEERS (Detroit Stoker Co.). U. S. 2,356,144, Aug. 22, 1944 (March 9, 1942).

Geology

Energies of solution of silica in water and HCl. P. G. NUTTING. *Jour. Chem. Phys.*, **12** [8] 347–48 (1944).—The solubilities of silica in water and acid at various temperatures depend upon the energies of association and dissociation of the various ions present, energies which are derivable from the solubilities by thermodynamic analysis. Data on the solubility of pure silica in water and HCl solutions have been formulated and reduced to energy as a step in the study of the solubility of the silicates. G.A.K.

Indium. R. P. GECKLER AND L. E. MARCHI. *Jour. Chem. Education*, **21** [8] 407–11 (1944).—The history, occurrence, properties, production, and uses of this rare metal are discussed briefly. 18 references. S.Z.

Uniformity factors in coating clays. C. G. ALBERT. *Paper Trade Jour.*, **118** [22] 105 (1944).—Because clay is the preponderant mineral material used in coating colors, its uniformity is of the utmost importance. Being a natural product, its properties must be regulated in the refining process, and at the same time sufficient blending should be accomplished to produce the greatest uniformity possible as it is sometimes impossible for the mills to make the necessary adjustments. W.R.B.

Chemistry and Physics

Applications of spot reactions: III, Use of sodium rhodizonate in the analysis of mineral products and alloys. F. FEIGL AND N. BRAILE. *Chemist-Analyst*, **32** [3] 52–59 (1943).—Sodium rhodizonate reacts with a neutral solution of a lead salt to form a blue-violet precipitate which changes to red at pH 3. One part of Pb in half a million can be detected. Insoluble lead salts also react at pH 3. Identification of lead sulfate; a direct test for lead in ores, minerals, pigments, and insecticides; and the identification of lead in glass and in alloys are described. When tin exceeds lead, it must be transformed into the stannic form. Sodium rhodizonate can be used to detect tin by the formation of the dark-violet stannous compound. **IV, Detection of elementary sulfur and selenium.** *Ibid.*, **33** [2] 28–31 (1944).—After extraction with carbon disulfide, pyridine, ether, etc., a drop of the solution is placed on paper impregnated with thallium sulfide. The reddish-brown product is resistant to dilute mineral acids and hydrogen peroxide. Selenium acts similarly to give a dark-brown to black speck. For Parts I and II see *Ceram. Abs.*, **22** [10] 182 (1943). A.P.

*** Circular slide rule for the evaluation of potentiometric investigations, especially of pH measurements with Jena glass electrodes.** L. KRATZ. *Z. Elektrochem.*, **48** [3] 132–34 (1942).—A slide rule based on Nernst's thermodynamic formula is described; it can be used in the range of pH 1.5 to 9.5 where the glass electrode has a linear dependence between the pH and potential changes. An example illustrates the application. M.HA.

*** Colorimetric determination of fluorine in simple and complex fluorides by means of zirconium-alizarin color lake: I and II.** F. RICHTER. *Z. Anal. Chem.*, **124** [5/6] 161–216 (1942).—The inaccuracies of present determination methods are eliminated by a new method using a color lake made of a solution of 17 gm. zirconium hydroxide in 170 cc. HCl and 700 cc. H_2O to which a solution of 4.2 gm. of Na alizarin-3-sulfonate in 500 cc. hot H_2O is added. As this lacquer contains Zr in excess, the free Zr always reacts first with F before the lacquer proper is attacked; this makes possible more exact F determinations. The preparation of reagents, the process, and evaluation are described in detail. M.HA.

Compendium of line pairs and operating conditions used in spectrographic analysis. E. S. HODGE. *Jour. Optical Soc. Amer.*, **33** [12] 656–59 (1943).—In working out methods for quantitative spectrochemical analysis, it will be useful to have information available on the best line pairs and operating conditions. H. presents a preliminary report of a compilation from most of the available literature. Application of the internal standard techniques of Gerlach or Lundegardh, or the homologous pair procedure, and statement of the concentration range and excitation source were criteria for whether a paper was to be abstracted. About 400 articles were reviewed at the source, and their data were recorded on small filing cards of various colors for the different types of analyses being studied. Nineteen items concerning the operating conditions were recorded. Data on the analysis of magnesium are presented in tables to illustrate the information collected. Another table indicates the type of information about unpublished findings which laboratories could contribute to the compilation. Publications ought to include all the information on the list. A.P.

*** Diffusion equations, their presentation in models, and diffusion experiments with silica gel: II, Diffusion in limited spaces at initial constant concentration.** ALFRED DOBROWSKY. *Kolloid-Z.*, **105,** 56–70 (1943).—A mathematical analysis giving numerous equations, tables, and diagrams enabling solution of diffusion problems is presented. M.HO.

Distribution of light intensity within a scattering medium. R. R. NEWTON. *Jour. Applied Physics*, **15** [9] 481–86 (1943).—An integral-differential equation gives the intensity within a scattering medium as a function of position and direction. A.P.

Effect of thixotropy on plasticity measurements. H. GREEN AND RUTH N. WELTMANN. *Jour. Applied Physics*, **15** [5] 414–20 (1944).—Rheological measurements of a thixotropic system present the following problems: (1) how to measure the magnitude of the thixotropic phenomenon, and (2) how to designate the state of structural breakdown of the material at the moment of measurement. These problems can be investigated by a thixotropic hysteresis loop. Laboratory procedures are given for recording plastic viscosity and yield value at a known "thixotropic level" and calculating the coefficients of thixotropic breakdown. In the rotation viscometer method, top speed (r.p.m.) and time of application are controlled so that the energy used in producing breakdown can be duplicated. The material must be conditioned, e.g., by aging, so that measurements are always started from the same level. A.P.

Exploring stress-strain relations of isotropic plastic solids. W. PRAGER. *Jour. Applied Physics*, **15** [1] 65–71 (1944).—In measurements of the stress-strain relations of a given plastic material, only certain stress resultants and certain local deformations are accessible, and reliable stress-strain relations can be established only if distributions of stress and strain are fairly uniform. Combined tension and torsion of thin-walled tubes constitute one of the few testing arrangements in which such conditions can be realized without too great experimental difficulties. A manner of representing the results graphically is used to discuss in geometrical terms some stress-strain relations proposed from the mathematical theory of plasticity. The possible effects of viscosity and strain hardening are discussed. More general methods of straining should be used in stress-strain studies on plastic materials. A.P.

Formation of bubbles. R. B. DEAN. *Jour. Applied Physics*, **15** [5] 446–51 (1944).—The formation of bubbles within liquids has received little attention from scientists because it is a nonequilibrium process and bubble nuclei are so generally prevalent. (It is important in glass, glaze, and enamel fusion, in gas opacification, and in other ceramic problems.) Extreme values for the negative pressures and the degrees of superheat that water will withstand without forming bubbles are contrasted with

* From microfilm.

the ease of forming bubbles by vibration or by turbulent flow. Bubble nuclei usually function by virtue of sorbed or trapped air. A technique for avoiding extraneous bubble nuclei is presented with some experiments on the formation of bubbles by mechanical action. A.P.

Improved electrode holder for spectrographic analysis. B. F. SCRIBNER AND C. H. CORLISS. *Jour. Optical Soc. Amer.*, **33** [9] 515–18 (1943).—For application in miscellaneous analyses, a versatile holder has been designed. A.P.

*** Influence of foreign gases on the thermal disintegration of calcium sulfate in the presence of silicic acid.** F. v. BISCHOFF. *Z. Anorg. & Allgem. Chem.*, **250** [1] 1–22 (1942).—The disintegration of $CaSO_4$ in the presence of SiO_2 in the molar ratio 1:1 at 1100°C. was investigated in air and in air and other gases at different temperatures; the reaction in the solid state between the two substances leads to the formation of calcium silicate. The most favorable medium for this reaction was found to be water vapor. M.HA.

Mounting of pigments for electron microscopy. M. L. FULLER, D. G. BRUBAKER, AND R. W. BERGER. *Jour. Applied Physics*, **15** [2] 201 (1944).—(1) Mull 0.01 gm. of the pigment on a glass plate, using 3 drops of a 1% by volume solution of poppy-seed oil in amyl acetate, until the paste is nearly dry. (2) Add 3 drops of 2% by weight solution of nitrocellulose in amyl acetate and mull until the solvent has evaporated. (3) Add 8 drops of a 2% solution of nitrocellulose in isopropyl acetate and mull for a few seconds. (4) Allow 1 drop of this suspension to spread on the surface of a saturated solution of sodium chloride in water. (5) Remove a portion of the resulting film on a glass slide, refloat it on water, and then attach it to the standard 200-mesh screen disk. A.P.

*** Origin of seams around particles viewed in an electron microscope and changes occurring in them as the focusing changes.** E. RUSKA. *Kolloid-Z.*, **105**, 43–52 (1943).—Pictures taken of ZnO needles by gradually changing the focusing of an electron microscope revealed that, as the focusing changes, bands appear on both sides of the particles. The width of these bands increases. The bands were previously attributed to reaction products or to layers of condensed evaporation products. By carefully changing the focusing, R. proves that these bands are images of Fresnel diffractions. 23 references. M.HO.

Oxyquinolate-cerate method for determination of aluminum. J. P. MEHLIG AND C. J. DERNBACH. *Chemist-Analyst*, **32** [4] 80–83 (1943).—A titrimetric method for aluminum consists in precipitating the oxyquinolate salt, dissolving it in perchloric acid, oxidizing the resulting 8-hydroxyquinoline with excess standard hexanitrato ammonium cerate solution, and titrating the excess with ferrous ammonium sulfate solution. A.P.

Physics in 1943. T. H. OSGOOD. *Jour. Applied Physics*, **15** [2] 89–107 (1944).—Progress in physics is reviewed under the following topics: (1) neutrons, (2) mesotrons, (3) disintegration by protons, (4) Cerenkov radiations, (5) ions, (6) thermal diffusion, (7) electron microscopy, and (8) X rays. A.P.

Polymer chemistry of silicates, borates, and phosphates. S. B. HENDRICKS. *Jour. Wash. Acad. Sci.*, **34** [8] 241–50 (1944).—The polymerism of the silicates, phosphates, and borates is discussed in terms of the various structural units in their lattices. In the phosphates and silicates, the unit is based on a tetrahedral group of 4 O ions around a central positive ion; in the borate unit 3 O ions are triangularly arranged around the B ion for the most common case. When O ions are shared, the polymeric groups are obtained. Closed groups, chains, and sheets are built up by repetition of these groups in a lattice. Numerous illustrations of model lattices are provided. 16 references. S.Z.

Properties of low-reflection films produced by the action of hydrofluoric acid vapor. F. H. NICOLL AND F. E. WILLIAMS. *Jour. Optical Soc. Amer.*, **33** [8] 434–35 (1943).—Chemical analysis, electron micrographs, and observations on the chemical solubilities and refractive-index requirements of the films produced on glass by exposure to dilute hydrofluoric acid vapor lead to the conclusion that the film is skeletonized silica. About 40% of a solid silica film must be removed to reduce its effective refractive index to 1.28. The holes are about 100 and 200 a.u. in size. A large number of glasses ranging from 30 to 80% SiO_2 have been successfully treated. On lead glass, the vapor-produced film brings about less residual reflection than is attained by the nitric acid leaching method. A vapor-treated surface tends to lose its properties if oil or grease contaminates the surface, but it can be restored by washing with soap and water. Low-reflection films produced by the HF-vapor process have high resistance to abrasion and to chemical attack. Their reflection may be as low as 0.2% for both high- and low-index glasses. The low scattering within the film insures a high light transmission. A.P.

Rapid determination of ferric and ferrous iron in the presence of copper and other ions. R. S. YOUNG. *Chemist-Analyst*, **32** [4] 79 (1943).—To a 250-ml. flask add 50 ml. water, 15 ml. 20% H_2SO_4, and a convenient measured volume of clear unknown solution. Titrate the ferrous iron with $K_2Cr_2O_7$, using diphenylamine or barium diphenylamine sulfonate as internal indicator. Then add a slight excess of copper metal precipitated powder, shake or stir for 2 min., filter, and titrate again for total iron. Fairly large quantities of other metals, such as cupric, Zn, Ni, Co, chromic, and manganous ions, have no appreciable effect. A.P.

Rheological properties of colloidal solutions, pigment suspensions, and oil mixtures. R. N. WELTMANN AND H. GREEN. *Jour. Applied Physics*, **14** [11] 569–76 (1943).—The law of Arrhenius, which correlates the viscosity of a colloidal solution logarithmically to the volume percentage concentration of solid matter, has been tested for higher concentrations of solids. Although the Arrhenius law could not be checked, a similar exponential law was evolved, correct within the tested region of viscosity. With increased solids, the suspension can become plastic or pseudoplastic and may be thixotropic. Where plasticity occurs, two exponential laws describe the relations between volume percentage of pigment content and the yield value or plastic viscosity. The equations are related to the average diameters of the pigment particles. A.P.

Sampling, mixing, and grinding techniques in the preparation of samples for quantitative analysis by X-ray diffraction and spectrographic methods. J. W. BALLARD, H. I. OSHRY, AND H. H. SCHRENK. *Jour. Optical Soc. Amer.*, **33** [12] 667–75 (1943).—For gross material, a diamond mortar and pestle, ore grinder, mixing cloths, and riffle are used for obtaining a small representative sample. For X-ray diffraction, a small portion of this material is mixed with an internal standard and reduced to homogeneous mixtures of satisfactory particle-size range in ball mills or in a motor-driven mortar and pestle. A ball-mill technique for mixing samples for spectrographic analysis minimizes the effects of sample inhomogeneities. The methods were developed for analyses of atmospheric dusts but are applicable wherever a few milligrams must be made to represent a large gross sample. A.P.

Solution of some problems of viscous flow. G. GREEN. *Phil. Mag.*, **35** [243] 250–62 (1944).—Detailed mathematical analysis is made of a number of problems of viscous flow within certain specified boundary conditions. G. discusses flow (*a*) within converging plane walls, (*b*) with hyperbolic boundaries, and (*c*) into a parallel channel. 7 references. S.Z.

Spectrochemical analysis of solutions using spark excitation. H. A. SLOVITER AND A. SITKIN. *Jour. Optical Soc. Amer.*, **34** [7] 400–404 (1944).—For the consumer applying spectrochemical methods to the inspection of a wide variety of materials, a spark-excitation method is recommended that utilizes a solution of the sample rather than the solid material itself. A.P.

Spectrographic determination of small amounts of

* From microfilm.

impurities in magnesium chloride. M. F. WILSON. *Jour. Optical Soc. Amer.*, **34** [4] 229–33 (1944).—The spectrograph may be utilized to great advantage for the rapid and accurate analysis of such impurities in magnesium chloride as boron, silicon, manganese, iron, aluminum, copper, sodium chloride, and calcium chloride. The time per determination is 4 min. when two samples are run on the same plate and 2.5 hr. for the complete analysis in triplicate. A.P.

Spot-reaction experiments: VII, Chemical paradoxes. F. FEIGL. *Jour. Chem. Education*, **21** [7] 347–49, 353 (1944).—Certain apparently "unorthodox" reactions are discussed, and detailed procedures are provided. (26) Hydrogen peroxide as a reducing agent (mutual reduction of two oxidants); the reactions of $KMnO_4$, NaOCl, and $Fe(CN)_6^{''''}$ with H_2O_2 are discussed (27) Sulfurous acid brings about oxidation; the reaction of H_2S and H_2SO_3 is given as an example. (28) Nitric acid is not an oxidant; it is claimed that the oxidizing power of HNO_3 can be attributed to the presence of nitrites and nitrogen oxides in the acid. (29) Aluminum forms hydrated aluminum oxide in the air; the well-known catalytic oxidation of Al in the presence of Hg and moisture is mentioned. (30) Nonvolatile oxides of Sn and Sb are made to disappear by heating with a volatile compound. When the oxides of Sn and Sb are heated with HI, the iodides formed can be volatilized. (31) An acid sets a base free from a salt: $H_3BO_3 + 4KF \rightleftarrows KBF_4 + 3KOH$. (32) $KMnO_4$ is not capable of oxidizing oxalic acid; the presence of MoO_3 in an oxalic acid solution gives rise to the insoluble H_2MoO_3-C_2O_4 complex. (33) Ammonium polysulfide brings about an oxidation. SnS is oxidized by complex formation with $(NH_4)_2S_x$. The reactions are mentioned as possible spot-test reactions in microanalytical work. For Part **VI** see *Ceram. Abs.*, **23** [9] 159 (1944). S.Z.

Strontia as a ceramic-glaze oxide. JOHN D. CLARK. *Foote-Prints*, **16** [1] 9–17 (1944).—Strontia will be available in large quantities at low cost. As a ceramic-glaze oxide, strontia has the following advantages: (1) When replacing CaO in a dinnerware glaze, it is a more active flux, increases fluidity, lowers softening temperature and solubility, and raises thermal expansion only slightly for either a molecular or a weight replacement. (2) When replacing ZnO, it retains the same softening temperature, lowers solubility, and slightly raises the thermal expansion. (3) When replacing PbO, it decreases fluidity, increases softening temperature, and slightly increases thermal expansion. Good glaze fit was obtained in all CaO replacements, but maximum increased fluidity and lowered softening results when SrO is added to the frit. Satisfactory leadless glazes can be obtained by additional soaking, but such glazes are more soluble unless crystallization of calcium and strontium silicates is retarded by increased multiplicity of the RO group. Other advantages claimed for strontia additions are mentioned. The firing range of high-lime glazes is extended. Viscous zirconium-containing sanitary-ware glazes can be smoothed. Glazes for low-temperature vitreous bodies are improved. Replacements for calcium and/or barium should promote interface reaction, improve glaze fit, increase glaze hardness and scratch resistance, lower solubility, and enable the glaze to clear with a minimum of pits and blebs. A.P.

* **Thixotropy of montmorillonite.** HELMUT G. F. WINKLER. *Kolloid-Z.*, **105**, 29–38 (1943).—An extensive study of thixotropy was carried out on a material known under its trade name as Toxiton. This material is a Na montmorillonite activated by a Na_2CO_3 treatment. The product is a relatively pure substance consisting of particles predominantly below 0.5 μ radius containing only few impurities in the upper limits of particle size (> 50 μ radius). As a measure of thixotropy, not the usual solidification time but the thixotropic limit was used (cf. *Ceram. Abs.*, **18** [4] 113 (1939)). The thixotropic limit is defined as the ratio V_fl/V_{sub}. V_fl is that volume of liquid which, combined with V_{sub} (volume of the solid substance) in a glass container of a definite diameter, produces a thixotropic system having a solidification time of exactly 1 min. By solidification time is understood the time required by the gel to solidify to a degree that it does not flow under the influence of gravity when the container is inverted. For determining V_{sub}, the specific gravity of montmorillonite is required. Because of intercrystalline swelling, the specific gravity of montmorillonite is higher in its air-dry state than it is in the liquid-submerged state. In this investigation it was accepted as 2. [Hoffmann, Endell, and Wilm ("Crystal . . . ," *ibid.*, **14** [4] 100 (1935)), give the specific gravity of dry montmorillonite as 2.1.] The thixotropic limit is very sensitive, as demonstrated by the following relationships: for values of V_fl/V_{sub} of 33, 24, and 36, the solidification time was 1, 6, and 45 min., respectively. The following relationship was derived from experimental values: $V_fl/V_{sub} = k_F \cdot \log$ solidification time, where k_F is a constant depending on the solid phase (particle size, mineral, etc.). The dependence of the thixotropic limit on the diameter of the container was determined in glass tubes with diameters ranging from 4 to 40 mm. The value of the thixotropic limit diminished gradually as the diameter of the tube increased. Within the limits of experimental error, the value of the thixotropic limit remained unaffected by the height of the suspension in tubes of equal diameter. This indicated that the factors determining the solidification of the system are equally distributed throughout this system. The effect of temperature on V_fl/V_{sub} was studied between 25° and 90°. As the temperature increased, the solidification time decreased rapidly, i.e., V_fl/V_{sub} increased, since for a given system V_fl had to be greater to give a solidification time of 1 min. When $\log V_fl/V_{sub} \times 10^2$ (ordinate) is plotted against $T \times 10^4$ (abscissa), the values fall on a straight line. The temperature effect is in accordance with the Arrhenius equation defining the temperature effect on chemical reactions, $\log k = (A/T) + H$. The effect of electrolytes on the thixotropic limits was studied with NaCl, KCl, NaOH, and KOH. With increasing concentrations of these salts, the value of V_fl/V_{sub} diminished, i.e., the thixotropic properties decreased. Hitherto no electrolyte has been found in the presence of which the thixotropic limit of montmorillonite is greater than in pure H_2O; thus, the thixotropic properties of montmorillonite are quite different from those of kaolinite and other mineral powders whose thixotropic properties are enhanced in the presence of some electrolytes. This difference in behavior manifests itself still more when the thixotropy of montmorillonite is compared with that of kaolinite, quartz, feldspar, fluorspar, and quartz glass in organic liquids. The thixotropy of the above-named group of minerals is known to increase in apolar liquids as compared with that in water. In benzene, xylene, heptane, and hexane, the thixotropic limit of these minerals increases in the order of the liquids listed. The thixotropy of montmorillonite and of kaolinite was studied in hexane, heptane, benzene, CCl_4, nitrobenzene, H_2O, MeOH, EtOH, iso-pentanol, BuOH, and sec.-octanol. The thixotropic limit of kaolinite in these liquids decreased in the order given from 21.4 to 3.3, being 10.4 in H_2O. The thixotropic limit of montmorillonite dropped from 40.0 in H_2O to 2.3 in all the other liquids. The thixotropic behavior of a substance in a given liquid is known to depend on the energy relationship at the solid-liquid interface. Even air-dry montmorillonite is known to contain approximately 18% H_2O; thus, in the case of montmorillonite, there is no solid-liquid interface but solids surrounded by a water envelope-organic liquid interface. When all the H_2O in montmorillonite was displaced by MeOH, its thixotropic limit (of this MeOH montmorillonite in analogy to H_2O montmorillonite) in MeOH rose to 20 and in a mixture of 30% benzene and 30% MeOH to 28.6. The thixotropic limit does not depend on the nature of the solid-liquid interface alone. An electrolyte solution contains ions and molecules. These are absorbed or bound by the montmorillonite particle and in turn become hydrated; thus the volume of H_2O bound by the montmorillonite increases further. This is demonstrated

* From microfilm.

by the difference in the thixotropic limit of hydrolyzed montmorillonite, i.e., H montmorillonite and alkali montmorillonite. Experiments further corroborating this point are quoted. The effect of the degree of dispersion on the thixotropy of mica and kaolinite was previously proved by the author (*ibid.*, **18** [4] 113 (1939)). As the particle size of a system decreases, its degree of thixotropy increases. This is explained by a change in the relation of the attracting and repelling forces of the solid particles. As the distance between particles increases, the repelling forces decrease very rapidly. As a result, the particles thus enjoy to the same extent a force-free mutual relationship. This state favors an increased volume of liquid. The effect of dispersion on the thixotropic limits was tested. The degree of dispersion was increased gradually by exposing montmorillonite gels to ultrasonic waves. The degree of dispersion was controlled by controlling the time of treatment with ultrasonic waves (0 to 180 sec.). At first the thixotropic limit increased rapidly, then the rise slowed down, and finally it reached a constant value beyond which it did not increase. Finally, the degree of solidification or the strength of a gel as affected by the concentration of solids in it was measured by determining the energy required to induce incipient liquefaction of a gel by sending through it ultrasonic waves. Throughout this experiment the time was kept constant (5 sec.), while the potential across the emitter was raised. The square of the voltage was the measure of the energy applied. As the volume of liquid/gm. of solids increased from 12 to 36, the values of volt$^2 \cdot 10^2$ decreased from 225 to 64; thus, the higher the solid content of a gel, the higher is its strength. M.Ho.

Twinning in zinc oxide. M. L. FULLER. *Jour. Applied Physics*, **15** [2] 164–70 (1944).—Twinning has been observed in crystals of zinc oxide produced by burning zinc vapor. With the aid of stereoscopic electron microscopy, the spatial arrangement of the components of the twinned crystal has been analyzed crystallographically. The particle consists of four needle-shaped crystals united at a common juncture, known as fourlings. Their spatial angles are explained on the basis of twinning on the (112) planes of the crystal lattice. A.P.

* **Ultramicroscopic images of the lamellar structure of magnesium hydroxide.** ANON. *Kolloid-Z.*, **105**, 226–27 (1943).—The lamellar structure of $Mg(OH)_2$ was proved in an electron microscope. The observed lamellas were 20 to 100 a.u. wide. These values are in good agreement with roentgenographic measurements of the so-called Arnfelt structure. M.Ho.

PATENTS

Process for the manufacture of strontium peroxide. AUGUST HUMMEL AND W. M. DRIESEN (Hummel Chemical Co., Inc.). U. S. 2,357,655, Sept. 5, 1944 (Sept. 15, 1942).

* From microfilm.

General

Aid to libraries in war areas. ANON. *Bull. Amer. Ceram. Soc.*, **23** [9] 332 (1944).

American Ceramic Society—its scope and functions. RALSTON RUSSELL, JR. *Bull. Amer. Ceram. Soc.*, **23** [9] 294–95 (1944).

George Kimball Burgess. ANON. *Bur. Standards Tech. News Bull.*, No. 183, pp. 63–64 (July, 1932); reprinted in *Bull. Amer. Ceram. Soc.*, **23** [9] 291–92 (1944).—1 photo.

Ceramic industry of southern California. FRED B. ORTMAN. *Bull. Amer. Ceram. Soc.*, **23** [9] 309–10 (1944).

Chemical Russian, self-taught: I, Suggestions for study methods. J. W. PERRY. *Jour. Chem. Education*, **21** [8] 393–98 (1944).—A general discussion of the alphabet, grammar, and idioms is given. Numerous examples of Russian chemical words, declensions, and idioms are included. S.Z.

Effect of the tendency to reduce engineering drawing time. A. S. LEVENS. *Jour. Eng. Education*, [N.S.] **30** [5] 496–505 (1940).—There has been a 30% decrease in the time allotted to drawing instruction in engineering curricula during the last two decades. The main difficulty in preventing this and further reductions is selling the importance of the subject to school administrations, not to industry. A poll of industry has shown that approximately 75% of the young engineering draftsmen have had insufficient drawing instruction. The weaknesses of present drawing courses are pointed out, and improvements are suggested for making the engineering student more useful in industry. E.W.R.

Electricity and metallurgy. L. SANDERSON. *Elec. Rev.*, **135** [3477] 61–62 (1944).—S. summarizes a number of recent developments in which the electrical and metallurgical fields have cooperated: (1) electric furnaces of higher output; (2) improvement of scrap through washing, briquetting, and the use of a roasting medium; (3) "solid" photoelectric cells for the measurement and control of high temperatures; (4) heating tops of steel ingots electrically; (5) metallic arc welding of high-sulfur steels with mild steel and dead-soft steel electrodes; (6) heliarc welding of stainless steel; and (7) metal-spraying method and the use of a powdered alloy for permanent magnets. M.R.

Engineer's view of engineering education. D. B. STEINMAN. *Jour. Eng. Education*, [N.S.] **31** [1] 18–41 (1940).—S. gives seven rather startling sketches of actual recent contacts with engineering education and its end products, illustrating effectively some of the shortcomings of engineering education. These shortcomings may be traced mainly to the fact that the objectives of engineering schools tend to be quantitative rather than qualitative. A much more careful selection of students for engineering training should be made, based on college entrance examinations in mathematics and physics—the two most important and indispensable high-school courses in the preparation for engineering study and application. There should also be a progressive raising of the admission standards in terms of high-school curricula and record, having as a final goal the following admission requirement: "Satisfactory completion of two years of pre-engineering study in the scientific course of a college of liberal arts and sciences, including successful completion of college physics, college chemistry, and calculus." The six-year engineering course is the logical solution to the present-day crowding of the engineering curriculum and the resultant deficiencies in many lines, particularly the basic sciences and humanistic and social studies. The six years would be divided as follows: (1) two years of pre-engineering college study, as entrance requirement to the engineering course; (2) two years of general engineering, at present third and fourth year college level, with more emphasis on basic engineering and less attempt toward specialization; the degree of Bachelor of Engineering (B.E.) would be conferred at this stage; and (3) two years of study in a major branch of engineering, ending in a degree of the type B.C.E. The merits of this proposed system are pointed out. A distinction is made between the training program for technicians (surveyors, draftsmen, inspectors, laboratory assistants, etc.), engineers, and executives. There is no need for their training to be identical, as is the case in many instances. Alluring enrollment propaganda distributed by engineering schools to high-school students is disapproved, and recommendations are made for engineers' registration and registration examinations. E.W.R.

Green spectacles. ALBERT BARNETT. *Optician*, **107** [2771] 213, 215 (1944).—Green spectacles were first recommended for eye comfort in 1586. In the early 1800's they became popular, but several writers criticized their indiscriminate use. Probably they were used to cover up uncorrected astigmatism. In the early 1900's, yellow-green Fieuzal tints were popular until the formulas by Sir William Crookes were published. A.P.

Hoist and sling chains. E. L. CADY. *Mech. Handling*, **31** [6] 256–61 (1944).—C. discusses the use of chains for lifting purposes, the characteristics of modern chains, storage facilities, and chain abuses. He concludes with rules for proper chain care. 2 diagrams, 5 photographs. M.R.

Institute of Ceramic Engineers: Report of Committee on Education. R. M. CAMPBELL, *Chairman. Bull. Amer. Ceram. Soc.*, **23** [9] 303–304 (1944).

Mobilization of scientific resources: III. ROSE V. HUTCHISSON. *Jour. Applied Physics*, **14** [8] 373–405 (1943).—Recent bills in Congress have proposed a drastic reorganization of the scientific agencies concerned with the war effort. To show the extent of mobilization which has already taken place, the logical setup and coordination of functions of the leading wartime civilian scientific organizations are described: (1) National Academy of Sciences, (2) National Research Council, (3) National Roster of Scientific and Specialized Personnel, (4) National Inventors' Council, (5) Office of Scientific Research and Development, (6) Office of Production Research and Development, and (7) National Advisory Committee for Aeronautics. **IV, The U. S. Navy.** *Ibid.*, **15** [3] 203 (1944).—Research in the Navy is described in a series of papers. **Organization of the United States Navy.** E. HUTCHISSON. *Ibid.*, pp. 205–208. **Research in the Navy.** Rear Admiral J. A. FURER. *Ibid.*, pp. 209–13. **Research in the Bureau of Ships.** Captain H. A. INGRAM. *Ibid.*, pp. 215–20. **U. S. Naval Research Laboratory.** Rear Admiral A. H. VAN KEUREN. *Ibid.*, pp. 221–26. **David W. Taylor Model Basin.** Rear Admiral H. S. HOWARD. *Ibid.*, pp. 227–35. **Naval Boiler and Turbine Laboratory.** Captain C. A. BONVILLIAN. *Ibid.*, pp. 236–39. **U. S. Navy Radio and Sound Laboratory.** Captain P. H. HAMMOND. *Ibid.*, pp. 240–42. **Navy Yard Laboratories, Bureau of Ships.** Comm. W. C. WAGNER. *Ibid.*, pp. 243–47. **Research in the Bureau of Ordnance.** Captain W. M. MOSES. *Ibid.*, pp. 249–54. **Research activities of the Naval Ordnance Laboratory.** Captain W. G. SCHINDLER. *Ibid.* pp 255–61. **Research and experimental activities of the U. S. Naval Proving Ground.** Captain D. I. HEDRICK. *Ibid.*, pp. 262–69. **Research in the Bureau of Aeronautics.** Capt. L. C. STEVENS. *Ibid.*, pp. 271–72. **Naval Air Matériél Center, Philadelphia, Pa.** J. W. MEADER. *Ibid.*, pp. 273–77. **Research in the Bureau of Supplies and Accounts.** Rear Admiral W. B. YOUNG. *Ibid.*, p. 278. **Research in the Bureau of Medicine and Surgery of the U. S. Navy.** Rear Admiral H. W. SMITH. *Ibid.*, pp. 279–88. **Research activities of the Bureau of Naval Personnel.** Rear Admiral L. E. DENFELD. *Ibid.*, pp. 289–90. A.P.

Owens-Illinois establishes pleasant employee-management relations by real understanding of problems. E. F. SULLIVAN. *Amer. Glass Rev.*, **63** [40] 26 (1944).—An effective personnel-relations program should provide wholesome recreation for the worker. The program in operation at the Columbus plant of the Owens-Illinois Glass Co. includes group insurance; a pamphlet which fully explains the company's spirit, policy toward workers, organization, layout, products, pay and promotion practices, housekeeping and safety, and medical service; a suggestion system; bulletin boards; a plant magazine; and a credit union. Each department posts its production for every day in the month and for the past year. In the restful ladies' locker rooms a hostess is selected for each shift from the girls working on that shift. Outside the main gate, an Onizers clubhouse provides auditorium, kitchen, and lounges. A.P.

Photoelastic demonstrations as teaching aids in strength of materials. MAX M. FROCHT. *Jour. Eng. Education*, [N.S.] **30** [7] 567–82 (1940).—F. shows that photoelastic demonstrations are effective aids to the teaching of a first course in the strength of materials in that they not only clarify the subject but aid and encourage advanced studies. The fundamental assumptions which are made in strength of materials may be demonstrated qualitatively and quantitatively by means of photoelastic stress patterns. Many photographs and five specific examples are given, with sufficient data to duplicate the experiments. E.W.R.

Repairs and maintenance: the hard-surfacing of conveyer worms. ANON. *Mech. Handling*, **31** [5] 219–20 (1944).—For many years the hard-surfacing of screw conveyers has been done with mild or medium carbon steel. Stellite is used now, and the effective lives of the screws have been increased considerably. Typical examples are given. Brief descriptions of the steps in the process are included. 3 photographs. M.R.

Research costs in educational institutions. EDWARD L. MORELAND. *Jour. Eng. Education*, [N.S.] **31** [4] 247–48 (1940).—The costs of research work at an educational institution may be divided into labor, materials, equipment, and overhead or undistributed costs. Overhead is difficult to determine. Methods of arriving at a figure for the cost of overhead are discussed. E.W.R.

Safety in quarry practice. A. J. R. CURTIS. *Pit & Quarry*, **37** [1] 87–89 (1944).—C. discusses the high accident-frequency rate prevalent in the quarrying industry and points out some of the natural and mechanical hazards which help bring about this high rate. He finds that 20% of the accidents occurred at the drills; 14% were due to flying, falling, or rolling rock, and another 14% resulted from injuries to men on rock piles; 13% happened at the shovels; 12% occurred around trucks; 10% at the railroad sidings; and the remaining 17% at miscellaneous points in the quarry. 6 references. M.R.

Symposium on technical library techniques: Importance of technical writing in chemical education. FLORENCE E. WALL. *Jour. Chem. Education*, **20** [12] 580–86 (1943).—63 references. **Problems of scientific literature research.** GUSTAV EGLOFF, MARY ALEXANDER, AND PRUDENCE VAN ARSDELL. *Ibid.*, pp. 587–92.—3 references. **Technical library and undergraduate research.** W. B. MELDRUM AND T. O. JONES. *Ibid.*, pp. 592–94.—4 references. **Slossonizing business and industry.** HOWARD A. MARPLE. *Ibid.*, pp. 594–96. **Literature service for fuel chemists.** JULIAN F. SMITH. *Ibid.*, pp. 596–98. **Use of microfilm in the research library.** ROSS C. CIBELLA. *Ibid.*, pp. 598–600.—21 references. **Importance of scientific literature in patent applications.** PAUL J. CULHANE. *Ibid.*, pp. 601–602. **Patent service; an arm of research.** WILFRED W. SMITH. *Ibid.*, pp. 602–604. **Contributions of the office of Alien Property Custodian to chemical research.** DEXTER NORTH. *Ibid.*, pp. 605–608. See *Ceram. Abs.*, **23** [2] 48 (1944).

Symposium No. 2 on technical library techniques: Opportunities for chemists in literature service work. L. SHORB AND L. W. BECK. *Jour. Chem. Education*, **21** [7] 315–19 (1944).—The various fields of reference work, abstracting and indexing, bibliographic work, patent searching, translating, and editing are discussed. **Library vs. the laboratory as a basis for research.** B. J. COLE. *Ibid.*, pp. 319–21. **Protection of the results of chemical research.** C. B. HOLLABAUGH. *Ibid.*, pp. 321–26.—H. discusses the procedure for patent application and prosecution and the procedure for interference application. **Use of Government publications in chemical research.** F. HARDEN. *Ibid.*, pp. 326–33.—A list of the Government bulletins is given. **Finding the literature.** B. A. SOULE. *Ibid.*, pp. 333–36. **Place of Russian scientific literature in bibliographic work.** J. G. TOLPIN. *Ibid.*, pp. 336–42.—T. discusses the types of literature and problems of transliteration. **Photoduplication service of the Army Medical Library.** H. W. JONES. *Ibid.*, pp. 342–44. **Editorial problems.** W. J. MURPHY AND S. ANDERSON. *Ibid.*, pp. 344–46. S.Z.

Teaching of labor relations. F. ALEXANDER MAGOUN. *Jour. Eng. Education*, [N.S.] **31** [3] 195–200 (1940).—M. emphasizes the importance of basing the course on the fundamentals of the subject rather than on memorization of detail. Suggestions are made as to the methods to be used and the principles to be taught. E.W.R.

Training engineers to handle men. MYRON H. CLARK. *Jour. Eng. Education*, [N.S.] **30** [10] 855–59 (1940).—C. deplores the young engineer's lack of training and ability to handle men and gives points which should be

covered in a course in human engineering or industrial relations for engineers. E.W.R.

Unit operations apparatus in mechanical laboratory instruction. R. A. SEBAN. *Jour. Eng. Education*, [N.S.] **31** [3] 213–24 (1940).—S. shows the importance of establishing laboratory work on the basis of the concept of unit operations and gives detailed information on the construction of apparatus to demonstrate several of the subdivisions of two unit operations. The examples given cover heat transfer (by conduction and by convection) and the mechanics of solids (dynamics). E.W.R.

Use, care, and maintenance of laboratory instruments. H. N. HAYWARD. *Jour. Eng. Education*, [N.S.] **30** [5] 506–10 (1940).—The various sources of error in laboratory instruments are as follows: positional errors, imperfect balancing, magnetized shields, pivot friction, temperature variations, magnetic fields (even through shielded instruments), aging, previous overloading, and improperly made calibration curves. Precautions are given for avoiding each. A service and repair record system is outlined and recommended, particularly for college laboratories. E.W.R.

PATENTS

Cleaning composition and process. M. I. BOWMAN AND HOWARD PACKER. U. S. 2,356,747, Aug. 29, 1944 (Feb. 12, 1943).—The process of cleaning machinery parts and similar hard surfaces of foreign matters such as carbon, grease, paint, dirt, etc., which process consists of applying thereto a composition comprising the following chemicals in approximately the following proportions by volume: neutral coal tar oil 40, monoethanolamine 15, oleic acid 15, ethylene glycol 15, ortho-toluidine 15, ethyl silicate 0.5, and phosphoric acid 0.5%; and thereafter removing the reaction product resulting from the applied composition in combination with the foreign matters to be removed.

Formula for a composition of ceramic matter. ROMILDO CASCIANI (one-third each to Max Bernstein, Jack Meltzer, and J. H. Funk). U. S. 2,356,214, Aug. 22, 1944 (July 25, 1941).—A ceramic composition consisting of the product formed by molding without heat and evaporating to dryness a mixture of and substantially in the proportions of 15 magnesite, 25 Florida clay, 26 talc, 4 bentonite, 15 asbestos, 5 silica, 3 dextrine, and 7 oz. of Portland cement with a solution of 5.5 oz. of calcium chloride and water.

CONTRIBUTIONS OF LIGHTING RESEARCH LABORATORY

LAMP DEPARTMENT OF GENERAL ELECTRIC COMPANY*

1911–1943

Section I. Radiant Energy Ultraviolet, Visible, Infrared

BOOKS

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Cooler foot-candles. Matthew Luckiesh. *Magazine of Light*, **7**, 23 (1938).

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THE BULLETIN SECTION

Volume 23 October 15, 1944 Number 10

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Ankeny, C. W., 205 W. Wacker Dr., Chicago 6, Ill.
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Atkins, Robert A., 117 Hartzell Ave., Niles, Ohio
Austenal Labs., Inc. (Paul F. Collins), 5932 Wentworth Ave., Chicago, Ill.
Austin, Alfred E. (Student), 168 Cedar St., Corning, N. Y.
Austin, Arthur O., Box 119, Barberton, Ohio
*Austin, Chester R., Battelle Memorial Inst., 505 King Ave., Columbus 8, Ohio
*Austin, James B., Research Lab., U. S. Steel Corp., Kearny, N. J.
Austin, Janet, 580 Washington Ave., West Haven, Conn.
†Austin, J. L., Carborundum Co., Niagara Falls, N. Y.
Austin, Lewis M., East Ave. & Oxford St., Vineland, N. J.
*Ayars, Alice A., 12479 Cedar Rd., Suite 201, Cleveland Heights, Ohio
†Aydelott, Elliott C., Murray Corp., 7700 Russell St., Detroit, Mich.

Baab, Kenneth A. (Student), 231 W. Tenth Ave., Columbus 1, Ohio
Babcock & Wilcox Co. (A. M. Kohler), 85 Liberty St., New York 6, N. Y.
Babcock, Clarence L., 1718 Potomac, Toledo, Ohio
Babcock, M. G., Pittsburgh Plate Glass Co., 2000 Grant Bldg., Pittsburgh 19, Pa.
†Babcock, Paul R., Frenchtown Porcelain Co., Frenchtown, N. J.
Bacher, Holland R., Rock Tavern, N. Y.
Bachman, Edith Carr, Carr China Co., Grafton, W. Va.
Bachman, Wheeler Carr, Carr China Co., Grafton, W. Va.
Backus, Lulu S., 451 S. Goodman St., Rochester 7, N. Y.
Bacon, J. L., Armstrong Cork Co., Millville, N. J.
*Badger, Alfred E., Dept. of Ceramic Engr., Univ. of Illinois, Urbana, Ill.
Baer, John G., 121 Kellogg St., Elsinore, Calif.
Baez, Jose D., Parque Lira 133, Tacubaya, Mexico City, Mexico
Bager, Frederic E., T. L. Smith Co., 2835 North 32nd St., Milwaukee, Wis.
*Baggs, A. E., Dept. of Fine Arts, Hayes Hall, Ohio State Univ., Columbus 10, Ohio
Bahnsen, Monroe J., 2111 Concord Dr., Lakewood 7, Ohio
Bailey, Cuthbert, Doulton & Co., Ltd., Burslem, Staffordshire, England
†Bailey, Floyd, 505 Bullocks Point Ave., Apt. 3, Riverside 15, R. I.
*Bailey, James, 95 Steele Rd., West Hartford 7, Conn.
Bailey, Capt. John A., Jr., New York, N. Y.
Bailey, R. F., Box 638, Hynes, Calif.
Bain, Andrew R., "The Whins," 26 Park Terrace, Stirling, Scotland
*†Bair, George J., Research & Development Dept., Corning Glass Works, Corning, N. Y.
Baker, Arvid H., 25 Pine St., Port Allegany, Pa.
Baker, Donald R., Box 73, Carrollton, Ohio
Baker, Houston R., 158 East 3rd St., Corning, N. Y.
†Baker, Martin, 513 Brady Ave., Apt. A, Barberton, Ohio
Balcom, Philip D., 124 Greenleaf St., Quincy, Mass.
Baldwin, William J., Crane Co., 836 S. Michigan Ave., Chicago 5, Ill.
*†Bales, C. E., Ironton Fire Brick Co., Ironton, Ohio
Balinkin, Isay A., Univ. of Cincinnati, Cincinnati 21, Ohio
Ball Brothers Co. (G. A. Ball), Muncie, Ind.
Ball, G. A., Ball Brothers Co., Muncie, Ind.
Baltimore Enamel & Novelty Co. (H. B. Little), Box 928, Baltimore, Md.
Bankson, John P., 1800 Farmers Bank Bldg., Pittsburgh 22, Pa.
Barger, H. D., 1248 Creighton Ave., Dayton, Ohio
Barkby, Harry, 217 Hillcrest Ave., New Castle, Pa.
*Barker, George J., College of Engr., Univ. of Wisconsin, Madison 6, Wis.
Barkwell, Bernard T., 3, Marstone Crescent, Totley, Sheffield, England
*Barlett, Helen B., A C Spark Plug Div., General Motors Corp., Flint 2, Mich.
Barnett, Lt. Charles W. H., New York, N. Y.
Barrett, Harvey N., Jr., 845 Hanna Bldg., Cleveland, Ohio
Barrett, Lionel R., Mellor Labs., Shelton, Stoke-on-Trent, England
Barrett, Maurice, 66, Norton Rd., Morecambe & Heysham, England
*†Barringer, L. E., General Electric Co., Schenectady 5, N. Y.
Bartholomew, Tracy, 1545 Beechwood Blvd., Pittsburgh 17, Pa.
Bartlett-Collins Co. (D. C. Hamilton), Sapulpa, Okla.
Bartlett, E. E., Box 141, Brownsville, Texas
Bartlett, Willard J., Glass Tech. Lab., General Electric Co., 1133 East 152nd St., Cleveland 12, Ohio
*Barton, G. E., 227 Pine St., Millville, N. J.
Bassett, Leon B., 41 W. University St., Alfred, N. Y.
Bassett, Robert, A. W. Whitford Co., Darlington, Beaver Co., Pa.
Bates, Charles, 128 Walnut St., Brookville, Pa.
Bates, Edgar A. (Student), 360 Westmoreland Rd., Snyder, N. Y.
Bates, Lt. E. E., Camp Davis, N. C.
Bates, H. Clifford, Research Enterprises, Ltd., Leaside, Ontario, Canada
*Bates, P. H., 3835 Livingston St., N. W., Washington 15, D. C.
Bates, A/C William S. (Student), Nashville, Tenn.
Batie, J. E., Kelsey-Hayes Wheel Co., 3600 Military Ave., Detroit 32, Mich.
†Baumann, Henry N., Jr., 1275 Wyoming Ave., Niagara Falls, N. Y.
Baumler, Karl, Medicine Hat Potteries, Medicine Hat, Alberta, Canada
Bausch & Lomb Optical Co. (Murray Scott), Rochester 2, N. Y.
Bay State Abrasive Products Co. (O. S. Buckner), Westboro, Mass.
Beals, M. Douglas, 33 Grove St., Perry, N. Y.
*†Beam, James R., 226 Euclid Ave., New Castle, Pa.

Beasley, Dennis R., Akro Agate Co., Clarksburg, W. Va.
Beasley, H. C., 3259 Kenmore Rd., Shaker Heights, Ohio
Beatty, Ross J., Jr., Black Hills Tin Co., Tinton, S. Dak.
Bechtner, Paul, American Colloid Co., 363 W. Superior St., Chicago 10, Ill.
Beck, J. Howard, 1800 Commonwealth Ave., Brighton, Mass.
Beck, Roy D., 738 Andover Rd., Mansfield, Ohio
Beck, Warren R., Ceramics Research Dept., Minnesota Mining & Mfg. Co., St. Paul 6, Minn.
Beckemeyer, Harry J. (Student), c/o Mrs. H. J. Beckemeyer, Box 106, Hillsboro, Ill.
Becker, Martin G., Box 542, Brookhaven, Miss.
*†Beecher, Milton F., Norton Co., Worcester, Mass.
Beeman, Earle A., 629 Buhl Bldg., Detroit 26, Mich.
Beeton, Earl E., 342 Murray St., Elizabeth 2, N. J.
Behrend, Oswald, 823 Park Ave., Vineland, N. J.
Behringer, Harold, Tygart Valley Glass Co., Washington, Pa.
Beinlich, Alfred W., House 109, Village 2, Sheffield, Ala.
Belden Brick Co. (P. B. Belden), Canton, Ohio
Belden, P. B., Belden Brick Co., Canton, Ohio
Bell & Howell Co. (R. B. Snyder), 7100 McCormick Blvd., Chicago 45, Ill.
Bell, Fred S., Box 242, Gleason, Tenn.
Bell, Ens. J. W., Palmatex Corp., Pinellas Park, Fla.
Bell, Leonard J., Georgetown, Ontario, Canada
†Bell, M. L., 3301 St. Paul St., Baltimore, Md.
Bell, W. C., Severna Park, Md.
Bellaire Enamel Co. (Charles Kapner), Bellaire, Ohio
Below, Henry, R. D. 1, Morrisville, Pa.
Benas, Mrs. F. M. (Student), 66 Potomac St., San Francisco, Calif.
Benner, Raymond C., Carborundum Co., Niagara Falls, N. Y.
Benner, W. J., 912 Pontiac Rd., Wilmette, Ill.
Bennett, Alva H., Spencer Lens Co., 19 Doat St., Buffalo, N. Y.
*†Bennett, A. Lee, 4407 52nd Ave., N. E., Seattle, Wash.
*Bennett, Dwight G., 204 Ceramics Bldg., Univ. of Illinois, Urbana, Ill.
Bennett, Frederick R., Box 325, Hartsville, S. C.
†Bennett, Myles P., 5088 Alhambra Ave., Los Angeles 32, Calif.
Bentley, Frederick, Trenton Potteries Co., Trenton 1, N. J.
Bergin, William M., Owens-Corning Fiberglas Corp., Ashton, R. I.
Bergmans, Carl, 601 Milwaukee Ave., South Milwaukee, Wis.
†Berkelhamer, Louis H., U. S. Bureau of Mines, Southern Expt. Sta., Tuscaloosa, Ala.
Berns, Milton H., 24 Oliver St., Hamburg, N. Y.
Berry, C. W., 104 Aberdeen Place, Clayton, Mo.
Besley, John S., Wabash River Ordnance Works, Terre Haute, Ind.
†Betz, George C., 131 Livingston Ave., New Brunswick, N. J.
Bevan, Arthur, Box 1428, University, Va.
Bevis, Ralph E., Gibraltar 1365, Villa Marconi, Avellaneda, F. C. S., Buenos Aires, Argentina
B. G. Corp. (Frank J. Fallon), Ridgefield, N. J.
Bhagat, M. G., 11 Rawdon St., Calcutta, India
Biberthaler, Max G., New Martinsville Glass Co., New Martinsville, W. Va.
Bickford, Fred A., 75 East 2nd St., Corning, N. Y.
Bickford, Lawrence R., Jr. (Student), 609½ W. Gray St., Elmira, N. Y.
Bicknell, R. S., 1516 Sunset Rd., Chattanooga 5, Tenn.
Biddulph, Albert, 11, Holden Rd., Penn, Wolverhampton, England
Bidwell, George E., 605 W. Martin St., Abingdon, Ill.
Bidwell, R. E., Abingdon Sanitary Mfg. Co., Abingdon, Ill.
Biggs, Henry C., Messrs. John G. Stein & Co., Ltd., Bonnybridge, Scotland
Binks Mfg. Co. (E. F. Watts), 3114 Carroll Ave., Chicago, Ill.
*†Birch, Raymond E., 1800 Farmers Bank Bldg., Pittsburgh 22, Pa.
Bishop, Frederic L., Jr., 301 Pershing Dr., New Kensington, Pa.
Black, H. R., Libbey Glass, Div. of Owens-Illinois Glass Co., Toledo 1, Ohio
Black, Lloyd V., 1006 Oregon Ave., Tarentum, Pa.
†Blackburn, A. R., Engr. Expt. Sta., Ohio State Univ., Columbus 10, Ohio
Blackburn, R. A., Robinson Ventilating Co., Zelienople, Pa.
†Blackwood, James M., 59 W. Royal Forest Blvd., Columbus, Ohio
Blaha, Emil, 133 Franklin Ave., Cheltenham, Pa.
Blair, Claude C., Metropolitan Paving Brick Co., Canton, Ohio
Blair, Marion W., 2131 S. Center St., Terre Haute, Ind.
Blake, A. E., 78 Park Ave., West Caldwell, N. J.
Blake, Edwin M., Box 210, Mount Kisco, N. Y.
Blake, William V., Macklin Co., Jackson, Mich.
Blanchard, M. Kenneth, A. O. Smith Corp., 3533 North 27th St., Milwaukee, Wis.
*Blau, H. H., Federal Glass Co., 515 E. Innis Ave., Columbus 7, Ohio
*†Bleininger, A. V. (Honorary, Charter Life), Homer Laughlin China Co., Newell, W. Va.
Blenko, W. H., Blenko Glass Co., Milton, W. Va.
Blessing, H. B., Emsco Refractories Co., 8601 Dorothy Ave., South Gate, Calif.
†Blewett, J. B., McLain Fire Brick Co., Wellsville, Ohio
Bliley Electric Co. (J. M. Wolfskill), Union Sta. Bldg., Erie, Pa.
Bliss, L. Ganong, 607 Custis Rd., Glenside, Pa.
Bloch, Joseph, J., Bloch & Sons, 157 Spring St., New York, N. Y.
Blodgett, Malcolm, 660 Main St., Woburn, Mass.
Bloor, C. A., Universal Clay Products Co., Sandusky, Ohio
Blount, Bruce, Box 1602, Univ. Sta., Austin 12, Texas
Blue Ridge Glass Corp. (J. H. Lewis), Kingsport, Tenn.
†Blume, Capt. Arthur J., Huntington, W. Va.
Blumenthal, George, Box 224, Trenton, N. J.
*Blunt, Royden A., Buck Glass Co., Fort Ave. and Lawrence St., Baltimore 30, Md.
†Boeker, V. W., Owens-Corning Fiberglas Corp., Nicholas Bldg., Toledo 1, Ohio
Boerner, A. R., 1762 East 45th St., Cleveland 3, Ohio
†Bognar, Edwin J., McKelvy-Bognar, Inc., 507 Oliver Bldg., Pittsburgh, Pa.
Bohn, Edward L., Box 58, Annex Sta., Cincinnati 14, Ohio
*Bole, George A., Engr. Expt. Sta., Ohio State Univ., Columbus 10, Ohio
Bolin, Edwin P., 440 W. North Ave., Elmhurst, Ill.
Bollinger, Robert H., 216 Hazelwood Ave., Bound Brook, N. J.
Bolton, Harry L., Philadelphia Quartz Co., 121 S. Third St., Philadelphia 6, Pa.
Bolz, Leonard H., 4128 Seventh St., Washington, D. C.
Bond, J. W. G., Pike Brothers, Ltd., Wareham, Dorsetshire, England
Bonnot Co. (B. T. Bonnot), Canton, Ohio
Bonnot, B. T., Bonnot Co., Canton, Ohio
Booth, Franklin, 1091 S. Oak Knoll Ave., Pasadena 5, Calif.
Booth, Seaver H., 40 Franklin St., Ansonia, Conn.
*†Booze, M. C., Charles Taylor Sons Co., Cincinnati 14, Ohio
Bopp, Harold F., 67 Gorton St., Corning, N. Y.
Boros, Lt. John (Student), Spence Field, Moultrie, Ga.
Bosazza, Vero L., 39 Barkly Rd., Parktown, Johannesburg, South Africa
Bossard, Albert G., 9 Houghton Circle, Corning, N. Y.
Botfield Refractories Corp. (A. H. Engstrom), Swanson & Clymer Sts., Philadelphia 47, Pa.
Botfield, George B., 210 Valley Rd., Merion Station, Pa.
Bovee, Benedict A., 220 74th St., Niagara Falls, N. Y.
Bowden, James J., 2538 E. Market St., Warren, Ohio
Bower, James A., First St., Chester, W. Va.

*Bowes, Urban E., Owens-Illinois Glass Co., 1700 N. Westwood Ave., Toledo, Ohio
Bowman, John G., Box 7, Schellsburg, Bedford County, Pa.
Bowman, Ralph M., Republic Steel Corp., Republic Bldg., Cleveland 1, Ohio
Bown, Lewis H., Carr China Co., Grafton, W. Va.
†Bowne, Martin S., Lee Clay Products Co., Clearfield, Ky.
Boyce, Robert E., Harker Pottery Co., East Liverpool, Ohio
†Boyd, John E., Box 52, Spruce Pine, N. C.
*†Boyd, Robert C., American Radiator & Standard Sanitary Corp., 1541 South 7th St., Louisville 8, Ky.
Boyle, Stanley H., 821 Payne Ave., Dunbar, W. Va.
Boyles, John P., 409 E. Lincoln Ave., New Castle, Pa.
Bradley, Alan L., Refractory Brick Co. of England, Ltd., Steetley, near Worksop, Nottinghamshire, England
Bradley, Charles A., Jr., 21 East 4th St., Corning, N. Y.
*†Bradley, Richard S., 4 Park Circle, Mexico, Mo.
†Bradwell, Cyril, 924 Timberman Rd., Columbus, Ohio
Brady, Lt. Col. Hugh J., Huntsville Arsenal, Huntsville, Ala.
†Bramlett, William P., Jr., 535½ North 3rd St., Millville, N. J.
Branda, Christopher, Refractory & Insulation Corp., Port Kennedy, Pa.
Brandow, Glen A., 69 W. Gibson St., Canandaigua, N. Y.
Brandt, Kristian H., Box 212, Red Bank, N. J.
†Brandt, William O., Gladding, McBean & Co., Box 630, Pittsburg, Calif.
Braun Corp. (J. G. Stewart), 2260 East 15th St., Los Angeles 21, Calif.
Braun, Julius, 300 N. Canal St., Chicago 6, Ill.
Braykovich, Andrew, Box 48, West Pittsburgh, Pa.
Brayton, Darlin E., 1450 Coast Blvd., S., Laguna Beach, Calif.
Breckenridge, James M., Vanderbilt Univ., Nashville, Tenn.
†Breeman, Leonard, Jr., Box 425, Bedford, Va.
Breene, George A., Industrial Colloids Co., Emlenton, Pa.
Breeze, Lewis K., 151 East 233rd St., Apt. 17, Euclid, Ohio
Brenner, Harold M., Box 519, Washington, Pa.
Brenner, R. F., Anchor Hocking Glass Co., Lancaster, Ohio
Bretz, Lewis A., 3332 N. Industry Rd., R. D. 5, Canton, Ohio
Brewster, H. M., 2825 N. Wolcott St., Chicago 13, Ill.
Brian, Charles, Paper Makers Importing Co., Inc., 640 North 13th St., Easton, Pa.
Brian, Richard, 422 Florida Ave., Chester, W. Va.
Brian, S. Douglas, Paper Makers Importing Co., Inc., 640 North 13th St., Easton, Pa.
Briganti, Lt. E. J. (Student), 100 Harrison St., San Francisco, Calif.
Brinckerhoff, J. E., Babcock & Wilcox Co., 85 Liberty St., New York 6, N. Y.
Brisch Brick Co. (Michael Brisch, Jr.), 228 N. LaSalle St., Chicago 1, Ill.
Brisch, Michael, Jr., Brisch Brick Co., 228 N. LaSalle St., Chicago 1, Ill.
British Ceramic Society, North Staffordshire Tech. College, Stoke-on-Trent, England
British Scientific Instrument Research Assn. (A. J. Philpot), 26, Russell Sq., London, W. C. 1, England
Britton, Marvin G., 201 Chemung St., Painted Post, N. Y.
Brockway Glass Co., Inc. (F. B. Hess), Brockway, Pa.
Bronson, James G., Westvaco Chlorine Products Corp., Chrysler Bldg., New York 17, N. Y.
Brooke, Frederick H., Oughtibridge, Sheffield, England
Brooks, Sidney J., Los Angeles, Calif.
Broomhall, Vincent, Andrews Place, East Liverpool, Ohio
Brosius, John P., Equitable Gas Co., 435 Sixth Ave., Pittsburgh 19, Pa.
Brouk, J. John, Hydraulic Press Brick Co., 705 Olive St., St. Louis, Mo.
Brown, Davis, Rm. 516, 426 S. Spring St., Los Angeles 13, Calif.
Brown, D. N. (Student), Sta. C, Box 4, Atlanta, Ga.
Brown, Donovan P., 12023 Lake Shore Blvd., Cleveland 8, Ohio
Brown, F. O., Dunbar Glass Corp., Dunbar, W. Va.
Brown, George R., North American Mfg. Co., 2910 East 75th St., Cleveland, Ohio
Brown, Horace T., 21 Park Dr., Fairmont, W. Va.
Brown, Joseph A., Baltimore Brick Co., 3601 E. Monument St., Baltimore 5, Md.
Brown, Julian T., Jr. (Student), 168 The Prado, N. E., Atlanta, Ga.
*†Brown, Lawrence H., Box 632, East Liverpool, Ohio
Brown, Leslie, Lenox, Inc., Trenton 5, N. J.
Brown, Sherwood F., 27 Johnson Heights, Waterville, Maine
*Brown, Wilbur F., Libbey-Owens-Ford Glass Co., 1701 E. Broadway, Toledo 5, Ohio
Brown, William A., Steele's House, Newcraighall Rd., Portobello, Edinburgh, Scotland
Brownell, Wayne E., 258 Charles St., Painted Post, N. Y.
Brownewell, George E. (Student), 2445 Elm Ave., Bexley, Ohio
Brownlow, James M. (Student), Rm. 4-241, Massachusetts Inst. of Tech., Cambridge, Mass.
Bruce, Charles F., 413 Center Ave., Verona, Pa.
Brumbaugh, W. Vernon, National Lime Assn., 927 15th St., N. W., Washington 5, D. C.
Brunning, Ernest J., Consumers Glass Co., Ltd., Box 210, Sta. B, Montreal, Quebec, Canada
Brunt, Albert E., 407 Jackson St., Minerva, Ohio
†Brush, George D., 35 E. Gay St., Columbus 15, Ohio
Brutsche, J. H., Bauer Pottery Co., Inc., 1800 Murphy Ave., S. W., Atlanta, Ga.
Bryant, C. W., Jr. (Student), c/o Prof. Lane Mitchell, Georgia School of Tech., Atlanta, Ga.
Bryant, Eugene E., 75 Cresswell, Bedford, Ohio
Buchholz, Russell A., Ocean Ave., Cape May Point, N. J.
Buck Glass Co. (R. A. Blunt), Fort Ave. and Lawrence St., Baltimore 30, Md.
†Buck, K. E., Ross-Tacony Crucible Co., Tacony, Philadelphia 35, Pa.
Buckles, Paul E., 1004 S. Main St., Fostoria, Ohio
†Buckner, O. S., Bay State Abrasive Products Co., Westboro, Mass.
Budnikoff, P. P., Pushkinskaya St. 79, Ufa, U. S. S. R.
Buffalo Pottery, Inc. (R. E. Gould), 1456 Seneca St., Buffalo 10, N. Y.
Bullock, C. L., Ohio Power Co., 112 West 5th St., East Liverpool, Ohio
Bunce, E. H., Tech. Library, Research Div., New Jersey Zinc Co., Palmerton, Pa.
*Burch, Oscar G., General Research Lab., Owens-Illinois Glass Co., 1700 N. Westwood Ave., Toledo 1, Ohio
Burchenal, Charles H., Cambridge-Wheatley Co., Lockland Sta., Cincinnati, Ohio
*†Burchfiel, B. M., 1153 Ruberta Ave., Glendale 1, Calif.
Burdett, R. E., American Crucible Co., Shelton, Conn.
Burdick, Robert B. (Student), 13 W. University St., Alfred, N. Y.
*Burgess, Blandford C., Box 395, Spruce Pine, N. C.
Burgner, Arthur J., Canadian Potteries, Ltd., St. Johns Quebec, Canada
Burke, L. R., 60 N. Harrison Ave., Pittsburgh 2, Pa.
†Burkhalter, Edward, Box 416, R. D. 8, Tacoma, Wash.
Burn, John H., 32, Mosley St., Newcastle-on-Tyne, England
Burnand, Guy M., Messrs. Johnson, Matthey & Co., Ltd., 78, Hatton Garden, London, E. C. 1, England
Burnham, Forrest E., Box 911, Alfred, N. Y.
Burns, Lt. (jg) Frederick L., 1319 N. Third St., Logansport, Ind.
Burroughs, F. H., Star Porcelain Co., Trenton 9, N. J.
Burrows, O. Mason, Highland Ave., Holden, Mass.
Burt, N. P., 400 Fifth Ave., Leavenworth, Kans.
Burt, Roland C., Germantown Manor, Apt. 806, Green and Hartter Sts., Germantown, Philadelphia, Pa.
*Burt, Stanley G. (Charter Life), Box 812, Stuart, Fla.
Bury, Thomas, 63 Higher Croft Rd., Lower Darwen, Lancashire, England

Bush, James W., 417 Eureka St., Pittsburgh 11, Pa.
Butcher, L. H., Co. (W. D. Schwartz), 2030 Bay St., Los Angeles, Calif.
Butchko, Thomas J. (Student), 138 S. Frazier St., State College, Pa.
Bute, Harold B., 4811 Indianapolis, East Chicago, Ind.
Butler, C. E., Jr. (Student), Box 853, Warrenton, Va.
Butler, F. W., Akron Porcelain Co., Akron 14, Ohio
Butler, James F., 2249 42nd St., Camden, N. J.
Butler, John, Hume, Va.
Butler, Thomas J., Jr., Box 279, Austin 2, Texas
Butler, William F., 3443 Valley Green Dr., Drexel Hill, Pa.
Butters, Philip W., 20 W. Lincoln Ave., Milltown, N. J.
Buzard, Fred T., Bell St., Plymouth, Ohio

Cable, Davis A., 245 21st Street, N. W., Canton 3, Ohio
*Cable, Margaret K., Univ. of North Dakota, Grand Forks, N. Dak.
Cadwallader, W. W., A. J. Lynch & Co., 2424 Enterprise St., Los Angeles 21, Calif.
†Cahoon, G. J., Knox Porcelain Corp., Knoxville, Tenn.
Cahoon, John B., Jr. (Student), 1555 E. 3350 South, Salt Lake City 5, Utah
Caito, Lt. A. M., 246 E. Maynard Ave., Columbus, Ohio
Cala, Charles F., 144 Hoover Rd., Rochester, N. Y.
Caldwell, Smiley, Jr., Adamston Flat Glass Co., Clarksburg, W. Va.
Caldwell, William D. (Student), 4629 Bayard St., Adrian Apts., Pittsburgh, Pa.
*†Callahan, H. D., U. S. Quarry Tile Co., East Sparta, Ohio
†Callinan, Edward E., 211 35th St., N. W., Canton 3, Ohio
Calton, R. G., Tennessee Enamel Mfg. Co., Park Ave. & Railroad, Nashville 9, Tenn.
Cambridge Glass Co., Cambridge, Ohio
Cameron, A. C., North East Fire Brick Co., North East, Md.
Campbell, Edward S., Northwestern Glass Co., 5801 E. Marginal Way, Seattle 4, Wash.
Campbell, G. Donald, Pittsburgh Plate Glass Co., Clarksburg, W. Va.
Campbell, Ian, California Inst. of Tech., Pasadena 4, Calif.
*†Campbell, Robert M., Alfred, N. Y.
Campbell, Thomas, R. Fowler, Ltd., Fitzroy St., Marrickville, Sydney, N. S. W., Australia
Campbell, Tom W., Box 255, Poland, Ohio
Campbell, Van E., 363 Highland Ave., Wadsworth, Ohio
Campbell, Verle (Student), R. D., Oakfield, N. Y.
Canfield, J. J., 2909 Orlando Dr., Middletown, Ohio
Canton Stamping & Enameling Co., Canton, Ohio
Capell, Robert G., Floridin Co., Warren, Pa.
Carborundum Co. (Otis Hutchins), Niagara Falls, N. Y.
*Carder, Frederick (Honorary), Steuben Div., Corning Glass Works, Corning, N. Y.
Carey, J. Sheldon, Dept. of Design, Univ. of Kansas, Lawrence, Kans.
Carlson, C. W., United States Glass Co., Tiffin, Ohio
Carlyle, Edward C., Box 128, Ironton, Ohio
Carnegie-Illinois Steel Corp. (J. C. Eckel), 922 Carnegie Bldg., Pittsburgh, Pa.
Carnes, Kenneth C., 2643 Wesleyan Dr., Toledo, Ohio
Carnes, Samuel J., Camark Pottery Co., Camden, Ark.
Carothers, R. B., H. C. Spinks Clay Co., Box 256, Newport, Ky.
Carothers, T. E., 4460 Mosher Ave., Los Angeles 31, Calif.
Carpenter, A. P., 121 5th St., N. E., Atlanta, Ga.
Carpenter, J. Hall, Humphreys Gold Corp., Mill Creek Rd., South Jacksonville, Fla.
Carr-Lowrey Glass Co. (Mrs. Bernice P. Moffett), Box 356, Baltimore 3, Md.
*†Carruthers, John L., Lord Hall, Ohio State Univ., Columbus 10, Ohio
Carter, Lt. Donald R., University Club, Akron, Ohio
†Carter, F. B., 515 S. Washington St., Tiffin, Ohio.
*†Carter, Herbert D., 3351 Dorchester Rd., Shaker Heights 20, Ohio
Carter, Wilber A., Detroit Edison Co., 2000 Second Ave., Detroit 26, Mich.
Cartwright, S. V., Whitacre-Greer Fireproofing Co., Waynesburg, Ohio
Casamo, Charles C., Sylvania Electric Products, Inc., Plant 3, Box 600, Warren, Pa.
Case, V. B., Paper Makers Importing Co., Inc., Easton, Pa.
Case, W. A., & Son Mfg. Co. (Willard G. Young), Robinson, Ill.
Casey, John F., Box 1888, Pittsburgh 30, Pa.
Caton, Albert J., Jr., 227 Clay St., Reno, Nev.
Caton, Milton W., 22490 Nevada Ave., East Detroit, Mich.
Cawood, Richard L., East Liverpool, Ohio
Cayford, James M., Glascote Products, Inc., 20900 St. Clair Ave., Cleveland, Ohio
Central Silica Co. (R. G. Hay), Zanesville, Ohio
Ceramic Color & Chemical Mfg. Co. (W. F. Wenning), Box 297, New Brighton, Pa.
Ceramics Publishing Co., Inc. (LeRoy W. Allison), Box 173, Newark, N. J.
*Cermak, Frank, 1542 Union St., Schenectady 8, N. Y.
Certain-teed Products Corp. (B. E. Fennessy), 120 S. La Salle St., Chicago 90, Ill.
Chadeyron, A. A. G., Cleveland Magnesite & Refractory Co., Ltd., Normanby, Middlesbrough, Yorkshire, England
Chaffee, Clare S., 3709 Liberty Blvd., South Gate, Calif.
Chamberlain, James M. W., Box 350, Akron 9, Ohio
Chambers, Gordon H., 1609 Summer St., Philadelphia, Pa.
Chambers, J. Fred, National Gypsum Co., Luckey, Ohio
Champion Spark Plug Co. (J. A. Jeffery), Ceramic Div., Butler Ave. and Grand Trunk R.R., Detroit 11, Mich.
Chandler, Harry L., 4340 41st Street, Camden, N. J.
Chantler, L. W., Standard Lime & Stone Co., Millville, W. Va.
Charbonnier, William P., Walsh Refractories Corp., 4070 N. First St., St. Louis 7, Mo.
Charman, Walter M., Ferro Engr. Co., 1208 Hanna Bldg., Cleveland 15, Ohio
Chattanooga Glass Co. (Frank Meacham), Chattanooga 10, Tenn.
Cherniak, Jack J. (Student), 628 Ave. H, S., Saskatoon, Saskatchewan, Canada
Chesler, I., 710 East 14th St., New York 9, N. Y.
Chesny, H. H., 130 East 75th St., New York 21, N. Y.
Chester, A. E., Promat Div., Poor & Co., 851 S. Market St., Waukegan, Ill.
Chesters, John H., Central Research Labs., United Steel Co., Stocksbridge, near Sheffield, England
Chicago Hardware Foundry Co. (Robert J. Young), North Chicago, Ill.
Chicago Pottery Co. (J. S. Clifford), 1920 Clybourn Ave., Chicago 14, Ill.
Chicago Retort & Fire Brick Co. (A. H. Taylor), 208 S. La Salle St., Chicago 4, Ill.
Chicago Vitreous Enamel Product Co. (William Hogenson), 1407 South 55th Court, Cicero, Ill.
Chilcote, Joseph H., 1907 16th St., N., Arlington, Va.
Child, J. L., Hancock Brick & Tile Co., Findlay, Ohio
Childs, Robert L., 89 E. First St., Corning, N. Y.
Chisholm, Boyd and White Co. (L. W. Flood), 57th and Wallace Sts., Chicago 21, Ill.
Chormann, O. I., 195 Gregory Hill Rd., Rochester, N. Y.
Christman, Brian B., 211 S. Sixth Ave., Butler, Pa.
Christman, C. E., Federal Enameling & Stamping Co., Pittsburgh, Pa.
†Christman, H. M., 1023 Roosevelt, N. E., Massillon, Ohio
Church, Marshall T., 200 Orange Dr., San Antonio 1, Texas
Claffey, Lawrence W., 1 S. East Ave., Vineland, N. J.
Clapham, Charles H., Jr., Rosalind Gardens, Apt. 1-D, Broadway, Dobbs Ferry, N. Y.
*†Clare, R. L., 212 Rector St., Perth Amboy, N. J.
Clark, Alec W., Wombwell Hall, near Barnsley, Yorkshire, England

Clark, C. Burton, 1464 Park Blvd., Apt. 12, Dormont, Pittsburgh 16, Pa.
Clark, G. D., Jr., N. Clark & Sons, 401 Pacific Ave., Alameda, Calif.
Clark, Horace N., Refractory & Insulation Corp., 120 Wall St., New York 5, N. Y.
†Clark, John D., Apt. 213, Jericho Manor, Jenkintown, Pa.
Clark, Leon L., 2043 W. Moreland Ave., Charlotte, N. C.
Clark, N., & Sons (G. D. Clark, Jr.), 401 Pacific Ave., Alameda, Calif.
Clark, Orrin H., Corning Glass Works, Corning, N. Y.
†Clark, Roland J., 4016 Hartel St., Philadelphia 36, Pa.
*Clark, William M., 16201 Brewster Rd., East Cleveland 12, Ohio
Clarke, Charles W., Box 441, Morton, Ill.
Clarke, Ford K., 5557 Beeler St., Pittsburgh 17, Pa.
Clay, Wilfred, 302 Patterson Court, Takoma Park, Md.
Claycraft Co. (C. Forrest Tefft), Box 866, Columbus 16, Ohio
Cleeves, George A., c/o E. W. Cleeves, 122 Missouri Ave., Somerset, Pa.
Cleghon, Charles C., 535 George St., Clyde, Ohio
†Clemens, Eugene C., Cannelton Sewer Pipe Co., Cannelton, Ind.
Clements, J. A., Shaws Glazed Brick Co., Ltd., Darwen, Lancashire, England
Cleveland Museum of Art, William M. Milliken, Sta. E, Cleveland 6, Ohio
Cleveland, Ens. H. M., New York, N. Y.
Cleveland, Theodore K., Sixth & Grayson Sts., Berkeley 2, Calif.
Cleverly, William B., Carborundum Co., Ltd., Trafford Park, Manchester, England
Clews, Francis H., Mellor Labs., Shelton, Stoke-on-Trent, England
Clifford, J. S., Chicago Pottery Co., 1920 Clybourn Ave., Chicago 14, Ill.
Cline, I. R., Western Brick Co., Danville, Ill.
†Cline, Robert W., 8 Upton Dr., Kensington, Md.
Coen, Bernard, Woodbridge Sanitary Pottery Corp., 500 Green St., Woodbridge, N. J.
†Coffeen, William W., 4820 Drummond Ave., N. W., Chevy Chase, Md.
Coffer, L. Wallace, Climax Molybdenum Co., Langeloth, Pa.
Coffin, Leon B., West School Lane, Yardley, Pa.
Coffman, William N., Keystone Abrasive Wheel Co., Ellwood City, Pa.
Cohen, Aaron (Student), 446 10th St., E., Prince Albert, Saskatchewan, Canada
Cohen, Arthur, Sylvania Electric Products, Inc., Emporium, Pa.
Cohen, Harvey L. (Student), Georgia School of Tech., Atlanta, Ga.
Cohen, Pfc. Irving I. (Student), Camp Claiborne, La.
Cohn, W. M., 8449 Terrace Dr., El Cerrito, near Richmond, Calif.
Colbert, William W. (Student), Dept. of Ceramics, Pennsylvania State College, State College, Pa.
Cole, Cpl. Grover, New York, N. Y.
Cole, G. Percy, Dominion Glass Co., Ltd., Box 190, Montreal, Quebec, Canada
*†Cole, Sandford S., National Lead Co., Titanium Div., Research Lab., Box 58, South Amboy, N. J.
†Coleman, Robert L., 2325 Fulton Ave., Davenport, Iowa
Coleman, Thomas B., 523 Beal St., Rocky Mount, N. C.
Collin, Robert (Student), N. Y. State College of Ceramics, Alfred, N. Y.
Collins, George F., Jr., Liberty Glass Co., 317 E. Lee, Sapulpa, Okla.
†Collins, Paul F., Austenal Labs., Inc., 5932 Wentworth Ave., Chicago 21, Ill.
Colonial Insulator Co. (R. W. Hemphill), 973 Grant St., Akron 11, Ohio
Columbia Fire Brick Co. (M. L. Hamaker), First National Bank Bldg., Canton, Ohio
Comeforo, Jay E. (Student), 18 Burgher Ave., Dongan Hills, Staten Island, N. Y.
Commercial Decal, Inc. (Alfred Duhrssen), East Liverpool, Ohio
*†Commons, Charles H., Jr., 508 Belmont, Watertown, Mass.
Conard, John B., 508 Woodward Ave., Mansfield, Ohio
Cone, Carroll, 3220 Indianola Ave., Columbus, Ohio
Connell, George A., 510 West 6th St., Los Angeles 14, Calif.
Conover, Ray C., Emsco Refractories Co., Lehi, Utah
Consolidated Feldspar Corp. (M. J. McHugh, Jr.), 1403 Trenton Trust Bldg., Trenton 8, N. J.
Cook, Charles S., Cook & Cook, First National Bank Bldg., Concordia, Kans.
*Cook, Herman L., O. Hommel Co., 209 4th Ave., Pittsburgh 30, Pa.
Cook, Mary E., St. Anthony's Hospital, 1450 Hawthorne Ave., Columbus 3, Ohio
Cook, Ralph L., 204 Ceramics Bldg., Univ. of Illinois, Urbana, Ill.
Cook, Roy J., 154 Poplar Ave., West Springfield, Mass.
Cook, Wilbur E., Wadsworth Brick & Tile Co., Wadsworth, Ohio
Cooper, Maurice A., Univ. of Witwatersrand, Johannesburg, South Africa
Cooper, William G., 723 Radnor Ave., Baltimore 12, Md.
Co-Operative Enameling Co. (H. C. Beasley), 2335 East 67th St., Cleveland, Ohio
Coors Porcelain Co. (A. Coors, Jr.), Golden, Colo.
Coors, A., Jr., Coors Porcelain Co., Golden, Colo.
Copeland, Ralph E., Steubenville Pottery Co., Steubenville, Ohio
†Copp, Warren F., Wheeling Steel Corp., Yorkville, Ohio
Corbin, Miss Juanita M., 569 Raymer Blvd., Toledo 5, Ohio
Cordes, John E., White Hall, Ill.
Corhart Refractories Co., Inc. (Fred S. Thompson), 16th & Lee Sts., Louisville 10, Ky.
Cornelius, Y. R., 13209 3rd Ave., N. W., Seattle, Wash.
Corning Glass Works (J. T. Littleton), Corning, N. Y.
Corning Glass Works, Charleroi Div. (Arthur W. Weber), Charleroi, Pa.
Corning Glass Works, Macbeth-Evans Div., Charleroi, Pa.
Cornish, Frank L. (Student), Box 284, Naples, N. Y.
Cornwell, George L. (Student), 26 Orchard Ave., Blasdell, N. Y.
Cosby, Lt. Adolphus B., San Francisco, Calif.
*†Coss, H. T., Johns-Manville Research Lab., Manville, N. J.
Coté, A. U., Cooksville Co., Ltd., Cooksville, Ontario, Canada
†Couch, Albert H., Libbey-Owens-Ford Glass Co., Rossford, Ohio
Couch, Everett G., Jr., Charles Taylor Sons Co., Cincinnati 14, Ohio
Courtney, Scott J., B. F. Drakenfeld & Co., Inc., 45–47 Park Place, New York 7, N. Y.
Covan, H. E., 396 Mimring Rd., Columbus 2, Ohio
Cowan, J. G., "Roselands," Billington, Haughton, Staffordshire, England
Cowell, J. Robert, Jr., Woodville Lime Products Co., 2140 Jefferson Ave., Toledo, Ohio
*†Cox, Paul E., Abrasive Co., Tacony and Fraley Sts., Philadelphia 38, Pa.
Cox, Samuel F., Research Lab., Pittsburgh Plate Glass Co., Creighton, Pa.
Craig, James W., Canadian Refractories, Ltd., 1050 Canada Cement Bldg., Montreal, Quebec, Canada
†Cramer, W. E., 965 West 5th Ave., Columbus 8, Ohio
†Crandall, Eugene R., 30 Pearl Hill, Milford, Conn.
†Crandall, James R., Central Research Labs., American Smelting & Refining Co., Barber, N. J.
Crandall, William B., N. Y. State College of Ceramics, Alfred, N. Y.
Crandon, A. S., American Window Glass Co., 16th Floor, Farmers Bank Bldg., Pittsburgh, Pa.
Crane Enamelware Co., Chattanooga, Tenn.

Crane, Robert F., Country Club Estates, Kittanning, Pa.
Craver, Howard H., Pittsburgh Testing Lab., Stevenson & Locust Sts., Pittsburgh 30, Pa.
*†Crawford, George E., 406 Belmont Ave., Haddonfield, N. J.
Crawford, J. C., Jr., Johns-Manville Sales Corp., 22 East 40th St., New York 16, N. Y.
†Crawford, J. L., Walsh Refractories Corp., 4070 North 1st Street, St. Louis 7, Mo.
Crawford, R. G., Homer Laughlin China Co., Newell, W. Va.
Creamer, Ansel S., National Bureau of Standards, Washington 25, D. C.
†Cress, W. C., Metallurgy Div., Armour Research Foundation, 33rd, Federal & Dearborn Sts., Chicago 16, Ill.
Crew, J. A., Masonic Temple, Zanesville, Ohio
Crockett, William E., 1224 Barber, Apt. 4, Little Rock, Ark.
Cromer, George W., 2307 N. Calvert St., Baltimore 18, Md.
Cronin China Co. (W. K. Cronin), Minerva, Ohio
Cronin, Neil E., Cronin China Co., Minerva, Ohio
Cronin, W. K., Cronin China Co., Minerva, Ohio
Crooks, Guy E., Crooksville China Co., Crooksville, Ohio
Crookston, James, c/o D. Morette, Benld, Ill.
Crooksville China Co. (Guy E. Crooks), Crooksville, Ohio
Croskey, Carl D., 5207 Garmouth Rd., Baltimore 29, Md.
Cross, Owen H., 319 East 4th St., Alton, Ill.
Crossley Machine Co. (William J. Harris), Trenton 9, N. J.
Crossman Co. (F. M. Crossman, Jr.), South Amboy, N. J.
Crossman, F. M., Jr., Crossman Co., South Amboy, N. J.
Crowell, Robert W. (Student), Texas A. & M. College, College Station, Texas
Crowley, Henry L., 1 Central Ave., West Orange, N. J.
Crown Potteries Co., Evansville, Ind.
Cruciana, F. L., Box 748, R. D. 1, Freedom, Pa.
Cruikshank, C. L., Great Lakes Foundry Sand Co., 720 United Artists Bldg., Detroit, Mich.
Crumbaker, H. G., Lancaster Lens Co., 220–226 W. Main St., Lancaster, Ohio
Crunden Martin Mfg. Co. (E. A. Schwarz), 760 South 2nd St., St. Louis 2, Mo.
Cullinan, Roland V., Olifantsfontein, Transvaal, South Africa
Cummings, John M., Dept. of Mines, Victoria, British Columbia, Canada
Cummins, Arthur B., 705 Ravine Rd., Plainfield, N. J.
Curll, Daniel B., Jr., Rumford Chemical Works, Rumford 16, R. I.
Currier, O. L., Leonard Refrigerator Co., Grand Rapids, Mich.
Curtis Labs., Inc. (T. S. Curtis), 2719 Hyperion Ave., Los Angeles 27, Calif.
Curtis, A. B., Johns-Manville Corp., 1530 Builders Exchange Bldg., 45 Prospect Ave., N. W., Cleveland 15, Ohio
Curtis, Algernon L., Westmoor Lab., London Rd., Chatteris, England
Curtis, Carl E., American Crucible Co., Shelton, Conn.
*Curtis, Thomas S., 2719 Hyperion Ave., Los Angeles 27, Calif.
†Curtis, Wesley E., Box 503, Woods Hole, Mass.
Curtis, W. F., Fostoria Glass Co., Moundsville, W. Va.
Curts, R. M., American Potash & Chemical Corp., 122 East 42nd St., New York, N. Y.
Cusick, Albert L., Jr., 1233 Jewett Dr., Zanesville, Ohio
Czechoslovak Ceramic Society, Brafova 11, Prague XIX, Czechoslovakia
Czolgos, Edmund P., Century Vitreous Enamel Co., 6641–6661 S. Narragansett, Chicago 38, Ill.

†Dager, Probert W., Edwin M. Knowles China Co., Newell, W. Va.
Dahlquist, Hugo A., Woodland Rd., Holden, Mass.
Dalton, Robert H., 234 Delevan Ave., Corning, N. Y.
D'Amico, Ens. Joseph D., Washington, D. C.
Dammann, Cpl. Richard (Student), Fort Monmouth, N. J.
Daniel, George R., 1535 South 5th St., Ironton, Ohio
*†Danielson, R. R., Metal & Thermit Corp., Carteret, N. J.
Danks, William H., 216 Mississippi Ave., Crystal City, Mo.
Dantzler, M. A., Rundle Mfg. Co., 3305 W. Forest Home Ave., Milwaukee 7, Wis.
Darby, George M., 61 Washington Ave., Westport, Conn.
Darrah, W. A., 901 N. Oak Park Blvd., Oak Park, Ill.
Davey, Earl R., Canadian Ohio Brass Co., Ltd., Niagara Falls, Ontario, Canada
†Davies, Chester A., 18 Loomis St., Montpelier, Vt.
Davies, Edward G., Dominion Glass Co., Ltd., Wallaceburg, Ontario, Canada
Davies, George S., Inland Firebrick Co., 3120 Berea Rd., Cleveland 11, Ohio
Davis Fire Brick Co. (D. D. Davis), Oak Hill, Ohio
Davis, D. D., Davis Fire Brick Co., Oak Hill, Ohio
*†Davis, Harry E., New Castle Refractories Co., Newell, W. Va.
Davis, H. M., Mineral Industries Bldg., State College, Pa.
Davis, James K., 26 East 3rd St., Corning, N. Y.
Davis, N. B., Rm. 512, 140 Wellington St., Ottawa, Ontario, Canada
Davis, Samuel L., Box 941, Glendale 5, Calif.
Davison, Albert W., 1119 Moundview Ave., Newark, Ohio
Day, Arthur L. (Honorary), 9113 Old Georgetown Rd., Bethesda, Md.
Day, Charles M., 208 N. Broadway, St. Louis, Mo.
Day, Frank, Jr., Corning Glass Works, Corning, N. Y.
†Day, Jack F., 1901 Dresden Rd., Zanesville, Ohio
†Day, Ralph K., Technical Dept., Libbey-Owens-Ford Glass Co., 1701 E. Broadway, Toledo 5, Ohio
Deaderick, James W., American Lava Corp., Chattanooga 5, Tenn.
†Dear, Paul S., Box 205, Blacksburg, Va.
†Debenham, William S., Carnegie-Illinois Steel Corp., 208 S. LaSalle St., Chicago 90, Ill.
Decker, Alfred R., 10814 McKinney Ave., Detroit 24, Mich.
Dedouch, J. A., 910 Keystone Ave., River Forest, Ill.
Deeds, C. L., Homer Laughlin China Co., Newell, W. Va.
Deeth, H. R., American Nepheline Corp., Box CH 67, Rochester, N. Y.
Deible, Clarence R., Marienville Glass Co., Marienville, Pa.
Delgado, Cyril B., 55 West 42nd St., New York 18, N. Y.
Demaison, R. J., Quigley Co., Inc., 527 Fifth Ave., New York 17, N. Y.
Demuth Glass Works, Inc. (W. R. Schlehr), Parkersburg Div., Box 629, Parkersburg, W. Va.
Deneen, W. F., North Carolina Feldspar Corp., Erwin, Tenn.
Denison Engr. Co. (W. C. Denison, Jr.), 1160 Dublin Rd., Columbus 16, Ohio
*Denison, George W., Box 1776, Newburg Sta., Cleveland, Ohio
Denison, W. C., Jr., R. D. 1, Powell, Ohio
Denny, Katherine E. (Student), 1407 East 45, Seattle 5, Wash.
Denver Sewer Pipe & Clay Co. (W. J. Geddes), Box 2329, Denver, Colo.
DePaolis, Paul F., 150 Longacre Rd., Rochester 5, N. Y.
Derge, Gerhard, Carnegie Inst. of Tech., Pittsburgh 13, Pa.
Deringer, W. A., 1913 E. Olive St., Milwaukee 11, Wis.
Derleth, C. P., F. E. Schundler & Co., Inc., Box 1145, Joliet, Ill.
†Derrer, Charles F., Jr., 11 Forest Ave., Elm Grove, Wheeling, W. Va.
Desaix, Herbert A., 320 East 7th St., Plainfield, N. J.
Deutsch, Eugene J., 923 N. LaSalle St., Chicago 10, Ill.
Deutsche Glastechnische Gesellschaft, H. Maurach, Gutletustrasse 8, Frankfurt, a. Main, Germany
Deutsche Keramische Gesellschaft, Mr. Knauf, Weglystrasse 1, Berlin, N. W. 87, Germany
DeVilbiss Co. (E. F. Frey), Toledo, Ohio
DeVoe, Charles F., 148 High Rd., Corning, N. Y.
Devol, M. Lee, Anthracite Industries, Inc., Primos, Delaware County, Pa.
DeWolf, Daniel W., 25 Beverly St., Rochester 10, N. Y.
Dexheimer, E. C. Box 6, Granite City, Ill.

Diack, George H., North American Refractories Co., Lock Haven, Pa.
Diamond Alkali Co. (C. W. Rippie), Research and Development Labs., Painesville, Ohio
Diamond Glass Co. (J. R. Hanson), Royersford, Pa.
*†Diamond, Grant S., 76 Rosedale Ave., Hamburg, N. Y.
Diaz, Efren, Apartado Nacional 475, Bogotá, Colombia
Dickens, H. A., Nilcrom Porcelains (Australia) Pty., Ltd., 221 Separation St. Northcote, Victoria, Australia
Dietrich, Waldemar F., 512 Baughman St., Claremont, Calif.
Diller, Charles C., 50 Strathmore Ave., Garret Park, Md.
Dillingham, H. L., American Glassware Assn., 19 West 44th St., New York 18, N. Y.
Ding, Yesun, National Resources Commission, 40 Wall St., New York 5, N. Y.
Dingledine, H. F., National Sewer Pipe Co., Ltd., Wentworth St., N., Hamilton, Ontario, Canada
Dingledy, David, 243 Buckingham St., Newark, Ohio
Dingwall, Andrew, 133 Front St., New York 5, N. Y.
Dippell, L. V., 1509 Hurlbut Ave., Detroit 14, Mich.
Dirlam, Arthur C., 218 Decatur St., Corning, N. Y.
Distillers Corporation, Ltd. (Adalbert Herman), 1430 Peel St., Montreal, Quebec, Canada
Dixon, Anna Lane, 815 North 4th St., Burlington, Iowa
Dixon, Fred W., Jr., Gunite Foundries Corp., Rockford, Ill.
Dixon, Joseph, Crucible Co. (H. P. Smith), Jersey City, N. J.
†Dlugozima, W. R., R. D. 6, Washington Pike, Knoxville, Tenn.
Dobrovolny, Frank J., Electrochemicals Dept., E. I. du Pont de Nemours & Co., Inc., Niagara Falls, N. Y.
Dodd, Arthur E., Mellor Labs., Shelton, Stoke-on-Trent, England
*†Dodd, Charles M., Dept. of Ceramic Engr., Iowa State College, Ames, Iowa
Dodge, Alfred W., Hazel-Atlas Glass Co., 126 Market St., Zanesville, Ohio
Doidge, Russell M., Morgan Crucible Co., Ltd., Battersea Works, Church Rd., London, S. W. 11, England
Doll, C. E., Mount Clemens Pottery Co., Mount Clemens, Mich.
Doney, Louis M. (Student), 204 Ceramics Bldg., Univ. of Illinois, Urbana, Ill.
Donnenwirth, A. L., Carborundum Co., Niagara Falls, N. Y.
†Doran, Robert, 108 W. Sixth St., Emporium, Pa.
Dornau, Fred F., 171–91 Wallabout St., Brooklyn, N. Y.
†Dornbach, W. E., 706 Edgewood Rd., San Mateo, Calif.
Dorsett, O. A., Knox Porcelain Corp., Knoxville, Tenn.
Dorsey, Baird L., 6625½ Church Ave., Pittsburgh 2, Pa.
Dorsey, Vernon M., Dorsey & Cole, 1346 F St., N. W., Washington, D. C.
Doty, Henry S., Kyanite Products Corp., 61 Broadway, New York 6, N. Y.
Dougan, Charles W., c/o P. A. Pedersen, R. D. 2, Hamilton, Mont.
Dougherty, Leon A., Box 712, Sun Prairie, Wis.
Dougherty, W. E., 53 N. Emily St., Pittsburgh 5, Pa.
Douglas, Freeman S., Babcock & Wilcox Co., Box 923, Augusta, Ga.
Douglas, John Co. (John F. Douglas), 71st Street and B.&O.R.R., Cincinnati, Ohio
Douglas, John F., John Douglas Co., 71st Street and B. & O.R.R., Cincinnati, Ohio
Dows, Robert H., 33 Washington St., Hornell, N. Y.
Drake, Arthur D., New Castle Refractories Co., New Galilee, Pa.
Drake, John L., Libbey-Owens-Ford Glass Co., 1701 E. Broadway, Toledo 5, Ohio
Drakenfeld, B. F., & Co., Inc. (Scott J. Courtney), 45–47 Park Place, New York 7, N. Y.
Draker, Harry C., 13614 Fourth Ave., East Cleveland, Ohio
Drayton, W. J., Sunshine Porcelain Potteries Pty., Ltd., Sunshine, Melbourne, Australia
*†Dressler, Philip, Swindell-Dressler Corp., Box 1888, Pittsburgh 30, Pa.
Drohan, William C., Yonkers, N. Y.
*†DuBois, H. B., Consolidated Feldspar Corp., 1403 Trenton Trust Bldg., Trenton 8, N. J.
Duckworth, Lt. Winston H. (Student), New York, N. Y.
Duevel, Charles O., Jr., American Thermos Bottle Co., Norwich, Conn.
Duhrssen, Alfred, Commercial Decal, Inc., East Liverpool, Ohio
Dunbeck, N. J., Eastern Clay Products, Inc., Eifort, Ohio
Duncan & Miller Glass Co. (James E. Duncan, 3rd), Washington, Pa.
Duncan, J. Earle, 1014 Linden Ave., Tarentum, Pa.
Duncan, James E., 3rd, Duncan & Miller Glass Co., Washington, Pa.
Duncan, Russell F., 2122 Russell Ave., Parma 9, Ohio
*Duncombe, George H., Jr., 150 E. Frambes Ave., Columbus, Ohio
Dunn, H. E., Vanadium Corp. of America, Bridgeville, Pa.
Duplin, Victor J., Jr., 300 North Ave., Fanwood, N. J.
Du Pont, E. I., de Nemours & Co., Inc. (S. C. Harris), Electrochemicals Dept., Wilmington, Del.
Durbin, Edmund A., 266 E. Torrence Rd., Columbus 2, Ohio
Durgin, Charles B., Monsanto Chemical Co., Anniston, Ala.
Dye, Harold A., San Diego, Calif.
Dyer, Mrs. A. R., 1644 Elberon Ave., East Cleveland 12, Ohio

*†Eagle, J. Eugene, 6306 20th Ave., Green Meadows, Hyattsville, Md.
Earhart, W. H., Decatur, Ill.
†Early, Joseph W., Early Foundry Co., Dickson City, Pa.
East, Walter (Student), 151 Maple Ave., Patchogue, N. Y.
†Easter, George J., 2434 South Ave., Niagara Falls, N. Y.
Easterby, E. D., Laurens Glass Works, Inc., Laurens, S. C.
Eastern Clay Products, Inc. (N. J. Dunbeck), Eifort, Ohio
Eastman Kodak Co., Research Library, Kodak Park Works, Rochester 4, N. Y.
Eatherton, C. Z., Pickard, Inc., Antioch, Ill.
Eckel, J. C., Carnegie-Illinois Steel Corp., 922 Carnegie Bldg., Pittsburgh, Pa.
Eckert, E. W., 224 West 4th Ave., Derry, Pa.
Eclipse Pioneer Div., Bendix Aviation Corp. (N. E. Woldman), Bldg. 1, Teterboro, N. J.
Eddy, Maxson A., Kimble Glass Co., Vineland, N. J.
Edgar Plastic Kaolin Co. (Albert C. Edgar), Metuchen, N. J.
Edgar, Albert C., Edgar Plastic Kaolin Co., Metuchen, N. J.
Edwards, F. Moorland, Porcelain Products, Inc., Carey, Ohio
Eggleston, Myron M., Alamo Pottery, Inc., 2150 Erie City Rd., San Antonio 7, Texas
Ehlers, G. Milton, 2206 E. Kensington Blvd., Milwaukee 11, Wis.
Ehman, Roy G., 960 Ninth Ave., Brackenridge, Pa.
Eide, Alwin C., Box 327, Columbus, Ohio
Eilers, H. F., 162 Watauga Ave., Corning, N. Y.
Ekdahl, W. Graydon (Student), 436 Second St., Renovo, Pa.
Ekholm, L. G., 929 Franklin St., McKeesport, Pa.
Elder, J. C., Robertson Mfg. Co., Box 848, Trenton 5, N. J.
Electric Auto-Lite Co., Spark Plug Div. (Robert Twells), Fostoria, Ohio
Electro Refractories & Alloys Corp. (Grant S. Diamond), 344 Delaware Ave., Buffalo 2, N. Y.
Ellefson, Bennett S., Sylvania Electric Products, Inc., 208–20 Cross Island Parkway, Bayside, Long Island, N. Y.
Eller, Clyde B. (Student), 400 North 18th St., Clarinda, Iowa
Ellerton, Hugh, "Montana," St. Margaret's Grove, Fenton, Stoke-on-Trent, England
Elliott, A. W., Covered Wagon Ranch, Cloverdale, Calif.
Elliott, F. R., 2821 Iowa Ave., Granite City, Ill.

Elliott, George, 10 Oakfield Rd., Cumbran, Newport, Monmouthshire, England
Elliott, William S., Dept. of Public Works, Municipal Bldg., New York, N. Y.
Ellis, James L., Ward McKee Engr., Ltd., 854 Eglenton Ave., W., Toronto, Ontario, Canada
Ellis, Richard B., 168 Cedar St., Corning, N. Y.
Ellis, Wilson H., Ceramic Dept., R. T. Vanderbilt Co., Inc., East Norwalk, Conn.
Ellison, Henry W., 12 E. Third St., Corning, N. Y.
Ellison, R. W., Vitrefrax Corp., 5050 Pacific Blvd., Los Angeles 11, Calif.
Ellsworth, E. J., Sierra Talc Co., 500 Union League Bldg., Los Angeles 12, Calif.
Elmer, Thomas H., 26 E. Third St., Corning, N. Y.
Elosua, Bernardo, Apartado 360, Monterrey, N. L., Mexico
Emanuel, E. C., Armstrong Cork Co., Central Technical Lab., Lancaster, Pa.
Emerson, G. S., Hampden Grinding Wheel Co., 118 Fisk Ave., Springfield 7, Mass.
Emerson, Walter H., Forsyth Place, East Liverpool, Ohio
Emison, M. Hershel, Corning Glass Works, Macbeth-Evans Div., Charleroi, Pa.
Emley, William S., 303 Englewood Ave., New Castle, Pa.
†Emrich, Emerson W., Clearview Park, Norwalk, Conn.
Emsco Refractories Co. (H. B. Blessing), 8601 Dorothy Ave., South Gate, Calif.
Engelhard, Charles, Inc. (A. W. Taber), 90 Chestnut St., Newark, N. J.
Engle, Chester C., United Clay Mines Corp., Trenton 6, N. J.
English China Clays Sales Corp., 551 Fifth Ave., New York 17, N. Y.
Engstrom, A. H., Botfield Refractories Corp., Swanson & Clymer Sts., Philadelphia 47, Pa.
Epstein, Edward, Jr. (Student), 1740 Rogers Ave., S. W., Atlanta, Ga.
Epsten, Lt. (jg) Stephen H. (Student), New York, N. Y.
Erickson, A. Alfred, 80 Pershing St., Corning, N. Y.
Erickson, Allen J. (Student), 4741 35th, N. E., Seattle, Wash.
Erie Resistor Corp. (Byron B. Minnium), 644 West 12th St., Erie, Pa.
Ernst, Louis, Louisville Fire Brick Works, 4554 Louisville Ave., Louisville 9, Ky.
Espinosa, Miguel (Student), Export Dept., Owens-Illinois Glass Co., Toledo 1, Ohio
Essick, Charles R., 700 Centre Ave., Reading, Pa.
Etherington, Alfred G., Sovereign Potters, Ltd., Hamilton, Ontario, Canada
Eubank, William R., Mellon Inst., Univ. of Pittsburgh, Pittsburgh, Pa.
Eureka Flint & Spar Co. (Herreld D. Thropp), Box 266, Trenton 2, N. J.
Eusner, George R., 319 Spruce St., Latrobe, Pa.
Euston, Jacob H., 79 W. Monroe St., Chicago 3, Ill.
Evans Lead Corp. (R. M. Evans), Box 1467, Charleston 25, W. Va.
Evans, Daniel O., Hillcrest and Linden Aves., Maple-view, Charleroi, Pa.
Evans, Richard F., 2300 Orange Cove, La Crescenta, Calif.
Evans, Robert E., 4320 Chester Dr., Youngstown 7, Ohio
Evans, R. L., George L. Ashworth & Brothers, Ltd., Broad St. Works, Hanley, Stoke-on-Trent, England
Evans, R. M., Evans Lead Corp., Box 1467, Charleston 25, W. Va.
Evans, Ross M., 913 S. Forrest Ave., Brazil, Ind.
*Everhart, J. O., Engr. Expt. Sta., Ohio State Univ., Columbus 10, Ohio
Exolon Co. (William A. Harty), Tonawanda, N. Y.
†Eyerly, George B., c/o William H. Eyerly, Jr., 382 W. Pine St., Canton, Ill.

*†Fabianic, William L., 1831 Seminary Ave., Alton, Ill.
Fabrica de Ladrillos Industriales y Refractarios, S. A. (Salvador Odriozola Gómez), Apartado 390, Monterrey, N. L., Mexico
*Fackt, George P., Box 936, Palos Verdes Estates, Calif.
†Fahrenbruck, William O., 149 Clinton Ave., Tiffin, Ohio
Failmezger, Howard, 96 Colonial Village Rd., Rochester 10, N. Y.
Fairchild, Charles O., C. J. Tagliabue Mfg. Co., Park and Nostrand Aves., Brooklyn 5, N. Y.
Fairchild, Theodore M., 339 Yale Ave., Johnstown, Pa.
Fairfacts Co., Inc. (M. P. Mitchell), Box 374, Trenton 3, N. J.
Falcao, Eric R., Caixa Postal 1448, Rio de Janeiro, Brazil
Falconer, Donald P., 45-15 Vernon Blvd., Long Island City 1, N. Y.
Falconer, Robert F., Box 38, El Segundo, Calif.
Falknor, Tom, Edgar Brothers Co., McIntyre, Ga.
Fallon, Frank J., 1085 Tuxedo Sq., Teaneck, N. J.
Falter, Arthur H., 8635 Jacob Place, Niagara Falls, N. Y.
Farncomb, Frederick J., 180 Princeton Ave., Corning, N. Y.
*Farnham, Dwight T., Green Orchard, Compo Rd., Westport, Conn.
Farren, Mabel C., 667 S. Carondolet, Los Angeles, Calif.
Faulkner, Karl B., Corning Glass Works, Corning, N. Y.
Faulkner, Richard (Student), 88-37 238 St., Bellerose, Long Island, N. Y.
Faust, Ernest, Jr. (Student), Highland, N. Y.
Faust, George T., 1803 Capitol View Ave., Silver Spring, Md.
Faust, William A. (Student), Ceramics Plant, Linde Air Products Co., Box 95, Kenmore, N. Y.
†Fay, Mervin A., 916 E St., Sparrows Point 19, Md.
Federal Glass Co. (Henry H. Blau), 515 E. Innis Ave., Columbus 7, Ohio
Federal Seaboard Terra Cotta Corp. (O. E. Mathiasen), Perth Amboy, N. J.
Fedock, Michael P., 1026 Market Ave., N., Canton, Ohio
*†Fellows, R. L., 748 N. Kensington Ave., La Grange, Ill.
†Fels, C. G., 70 Catalpa Ave., Perth Amboy, N. J.
Fenner, Alice C., Cranston-Fenner Studio, New Preston, Conn.
Fennessy, B. E., Certain-teed Products Corp., 120 S. LaSalle St., Chicago 90, Ill.
Fenton Art Glass Co. (F. M. Fenton), Williamstown, W. Va.
Fenton, F. M., Fenton Art Glass Co., Williamstown, W. Va.
Fenton, Walter M., Metalloy Corp., 1320 Rand Tower, Minneapolis, Minn.
Ferdinand, George, 750 N. Euclid Ave., Ontario, Calif.
Ferguson, J. N., 206 Watauga Ave., Corning, N. Y.
Ferguson, Robert F., 1010 Findley Ave., Zanesville, Ohio
Ferguson, Robert L., 730 Stuart Bldg., Lincoln, Neb.
Ferguson, R. W., Star Porcelain Co., Muirhead Ave., Trenton 9, N. J.
Ferro Enamel Corp. (R. A. Weaver), 4150 East 56th St., Cleveland 5, Ohio
Ferro Enamels (Australia) Pty., Ltd. (R. M. Mueller), Bourke Rd., Alexandria, N. S. W., Australia
Ferro Engr. Co. (Walter M. Charman), 1208 Hanna Bldg., Cleveland 15, Ohio
Ferrosmalt, S. A. (Antonio Orlando), Avenida 18, Julio 1202, Montevideo, Uruguay
Fervier, A. F., Box 510, 920 Charles St., Wellsburg, W. Va.
*†Fessler, A. H., Fenton, Mich.
Fettke, Charles R., 1118 Wightman St., Pittsburgh 17, Pa.
Field, Theodore E., 16th & Lee Sts., Louisville 10, Ky.
Fields, W. H., 405 Catherine St., Joliet, Ill.
Filippi, Charles R., Monticello, Ill.
*Filippi, Hugo, 228 N. LaSalle St., Chicago 1, Ill.
Finch, Katherine S., 121 Coast Highway, Corona Del Mar, Calif.
Findlay Clay Products Co. (John L. Leech), Washington, Pa.
Fischer, Eugene H., Masonic Apt. 2A, Latrobe, Pa.
Fischer, Kermit, R. D. 1, Doylestown, Pa.
Fisher, Helen, 1956 S. Coast Blvd., Laguna Beach, Calif.
Fisher, Henry C., 1 New Bond St., Worcester 6, Mass.
Fisher, Joseph R., Bell Telephone Labs., Murray Hill, N. J.

Fisher, W. V., Anchor Hocking Glass Corp., Lancaster, Ohio
†Fisk, Henry G., Univ. of Wyoming, Laramie, Wyo.
Fitch, William H., Plainfield National Bank Bldg., Plainfield, N. J.
†Fitzgerald, Alexander E., A4-Avon Apts., Narberth, Pa.
Fitzgerald, John V., 212 Walnut St., Corning, N. Y.
Fitzpatrick, William D., Newport News, Va.
Fitzsimmons, Elmer S. (Student), R. D. 1, Oakfield, N. Y.
Fix, Frank A., Lancaster Iron Works, Inc., Lancaster, Pa.
Flannigan, Alice M., Box 262, Alfred, N. Y.
Fleck, E. M., Vitro Mfg. Co., Corliss Sta., Pittsburgh, Pa.
Flick, Fulton B., 1706 First National Bank Bldg., Pittsburgh, Pa.
*†Flint, Francis C., Hazel-Atlas Glass Co., 319 S. Main St., Washington, Pa.
Flood, L. W., Chisholm, Boyd & White Co., 57th and Wallace Sts., Chicago 21, Ill.
Florence, Lt. Jack M., 6819 Kindred St., Philadelphia 24, Pa.
Flowers, E. B., 811 Drewry St., N. E., Atlanta, Ga.
Flu, Eldon B., 1533 Crooks Rd., Royal Oak, Mich.
Fogelberg, Sven, Webb's Crystal Glass Co., Ltd., Dennis Glassworks, Stourbridge, England
Foglesong, Howard D., 722 14th St., Box 432, Huntington, W. Va.
Fonoroff, Bernard, 1427 West Virginia Ave., N. E., Washington 2, D. C.
Foote Mineral Co. (H. C. Meyer), 1609 Summer St., Philadelphia, Pa.
†Foote, Earl H., Jr., Box 1092, Charleston 24, W. Va.
Foote, Paul C., 5036 Drexel Blvd., Chicago 15, Ill.
Ford, George D., 2136 Wilmer St., Zanesville, Ohio
Ford, George E., A. P. Green Fire Brick Co., 50 Church St., New York 7, N. Y.
†Ford, Walter D., 219 Maple St., Port Allegany, Pa.
Ford, William D., 126 N. Stone Ave., La Grange, Ill.
Fordham, Elmo A. (Student), 507 Perry St., Watkins Glen, N. Y.
Fords Porcelain Works (I. A. Hansen), Perth Amboy, N. J.
Foresman, Grover C., 220 Cedar St., Corning, N. Y.
Forester, W. G., Box 974, Trenton 6, N. J.
Forman, L. P., Delaware Apts., Oakmont, Pa.
Forse, Edwin B., Carborundum Co., Box 248, Perth Amboy, N. J.
Forst, Edward, Jr., 2820 S. Spaulding Ave., Chicago, Ill.
Forter, Samuel A., 119 Federal St., N. S., Pittsburgh 12, Pa.
*Fosdick, Marion L., N. Y. State College of Ceramics, Alfred, N. Y.
Foss, Feodore F., Wheeling Steel Corp. Bldg., Suite 412–19, Wheeling, W. Va.
Foster-Forbes Glass Co. (F. R. Motsch), Marion, Ind.
Foster, H. B., Jr., Washington, D. C.
†Foster, Harry D., 3116 Rodman St., N. W., Washington 8, D. C.
Foster, John A., 9591 Sorrento Ave., Detroit 27, Mich.
Foster, Wilfrid R., 8525 Butler Ave., Detroit 11, Mich.
Fostoria Glass Co. (W. F. Curtis), Moundsville, W. Va.
Fox, Eli, 59 Washington St., Dorchester, Mass.
Frahme, Herman H., Dogwood Lane, Union Village, R. D., Scotch Plains, N. J.
Francis, Marcus, British Pottery Research Assn., Stoke-on-Trent, England
†Francisco, Allen C., c/o N. W. Fredericks, Jr., 104 W. Main St., Lock Haven, Pa.
Franck, Charles, Holophane Co., Inc., 342 Madison Ave., New York 17, N. Y.
Frank, John N., Sapulpa, Okla.
†Frankel, H. D., Laclede-Christy Clay Products Co., 120 East 41st Street, New York, N. Y.
Franklin Glass Corp. (A. L. Pasquier), Box 150, Butler, Pa.
Frantz, Samuel G., 161 Grand St., New York 13, N. Y.
Franz, Hemming, Johnson, Vt.
Franz, Leo J., Acme Brick Co., Malvern, Ark.
Fraser, Walter A., Bausch & Lomb Optical Co., Glass Plant, Rochester 5, N. Y.
Fraser, W. B., Box 144, Dallas 1, Texas
Frazier-Simplex, Inc. (C. E. Frazier), 436 E. Beau St., Washington, Pa.
*Frazier, C. E., Frazier-Simplex, Inc., 436 E. Beau St., Washington, Pa.
Frazier, C. T., 527 E. Beau St., Washington, Pa.
*†Frazier, J. Earl, Frazier-Simplex, Inc., 436 E. Beau St., Washington, Pa.
*Fréchette, Howells, Bureau of Mines, Ottawa, Ontario, Canada
Fréchette, Van Derck, N. Y. State College of Ceramics, Alfred, N. Y.
†Frederick, C. L., Jr., 1373 N. Hudson St., Apt. 1 H, Chicago, Ill.
Frederick, Gilbert M., Babcock & Wilcox Co., Packard Bldg., Philadelphia, Pa.
Freed, Harold (Student), Gamma Sigma Phi, State College, Pa.
†Freeman, Charles A., A. P. Green Fire Brick Co., Mexico, Mo.
Freeman, H. S., Square D Co., 6060 Rivard St., Detroit, Mich.
Freeman, Joseph, 3012 Germantown Ave., Philadelphia, Pa.
Freese, H. H., E. M. Freese & Co., Galion, Ohio
Freiman, Joseph C. B. (Student), 97 Grand Ave., Newark, N. J.
Freitas, Lafayette de, Industria Brasileira de Artigos, Refractarios S/A, Rua Marconi 23, 6° andar, sala 1 e 2, São Paulo, Brazil
French Saxon China Co. (W. V. Oliver), Sebring, Ohio
*French, Myrtle M., 8301 S. Langley Ave., Chicago 19, Ill.
†French, Preston W., 200 Milliken Rd., Pittsburgh 21, Pa.
Frey, E. F., DeVilbiss Co., Toledo, Ohio
Frey, Laurel C., 77 W. Summit St., Alliance, Ohio
Friedman, Louis K., 1320 Bennington Ave., Squirrel Hill Sta., Pittsburgh, Pa.
*†Fritz, E. H., 710 Walnut St., Latrobe, Pa.
Fromer, Charles H., Park Ave., R. D. 7, Library, Pa.
Fronczak, Edwin T., 197 Pittsburgh St., Uniontown, Pa.
Frost, Leon J., Box 138, Lewiston, N. Y.
Fry, Herbert G., National Enamels, Ltd., 53, Norman Rd., Greenwich, London, S. E. 10, England
Fuenzalida, Javier H. (Student), N. Y. State College of Ceramics, Alfred, N. Y.
*Fulcher, Gordon S., 48 Elm St., Springfield, Vt.
†Fuller, Donald H., 228 Lalor St., Trenton 10, N. J.
Fuller, F. W., National Engr. Co., 549 W. Washington Blvd., Chicago 6, Ill.
Fulper Pottery Co. (J. M. Stangl), Trenton 4, N. J.
*†Fulton, C. E., Pittsburgh Plate Glass Co., Creighton, Pa.
Fulton, Glen B., Alliance Porcelain Products Co., Alliance, Ohio
Funnell, John E., 334 Culfor Crescent, Norfolk 3, Va.
Furgason, Carl M., 2004 E. Wichita St., Austin 21, Texas
Fyfe, Charles W., Mullite Refractories Co., Shelton, Conn.

Gaffney, Robert F. (Student), Box 54, Alfred, N. Y.
Gagnon, R. A., E. I. du Pont de Nemours & Co., Inc., Newport, Del.
Gaines, J. M., Linde Air Products Co., East Park Dr. and Woodward Ave., Tonawanda, N. Y.
Galanis, Terry, 161 Sixteenth St., Buffalo, N. Y.
Galbraith, Robert, Electrochemicals Dept., E. I. du Pont de Nemours & Co., Inc., Wilmington, Del.
Galbreath, William W., Jr., 142 Garden Rd., Norris, Tenn.
Gallagher, William, Pennsylvania Bottle Co., Sheffield, Pa.
Gallion, F. J., Haynes Stellite Co., Research Dept., Kokomo, Ind.
†Gallup, John, RCA Victor Div., Radio Corp. of America, 415 S. Fifth St., Harrison, N. J.
*Galpin, Sidney L., 44 Jones Ave., Morgantown, W. Va.
Galusha, Richard L. (Student), 1711 18th St., N. W., Washington 9, D. C.
Gamble, Lt. (jg) Elton S., San Francisco, Calif.
Ganapule, Anant K., Parshuram Pottery Works Co., Ltd., Morvi, Kathiawar, India

Gangler, James J. (Student), 4044 41st Ave., S. W., Seattle, Wash.
Garbisch, N. S., Garco Products, Inc., Butler, Pa.
Garco Products, Inc. (N. S. Garbisch), Butler, Pa.
Garden, Henry R., Jr., Salem, Va.
Garland, William, Johnson Glass Co., 5248 Elston Ave., Chicago 30, Ill.
Garrison, John W., Lab. Tech., U. S. Naval Air Facility, Columbus 3, Ohio
Garson, F. J., New Jersey Porcelain Co., Box 908, Trenton 5, N. J.
*†Garve, T. W., 314 King Ave., Columbus, Ohio
Garvey, Pfc. Lawrence P. (Student), Box 214, Cambridge 39, Mass.
Gaskins, W. W., Glendale, Calif.
Gast, Olga M. (Student), 13820 Othello Ave., Cleveland 10, Ohio
Gates, Major E., 331 McHenry Ave., Crystal Lake, Ill.
†Gates, Ross W., Tuscola, Ill.
Gauger, Alfred W., Pennsylvania State College, State College, Pa.
Gaunt, Charles L., Indiana Glass Co., Dunkirk, Ind.
Gayner Glass Works (John M. Gayner), Salem, N. J.
Gayner, John M., Gayner Glass Works, Salem, N. J.
Geddes, William J., Denver Sewer Pipe & Clay Co., Box 2329, Denver, Colo.
Gehrke, Edward W. (Student), Klan Alpine Fraternity, Alfred, N. Y.
*†Geiger, Charles F., Carborundum Co., Box 268, Perth Amboy, N. J.
Geiger, Joseph S., 681 76th St., Niagara Falls, N. Y.
*Geisinger, E. E., Pfaudler Co., 89 East Ave., Rochester 4, N. Y.
*†Geller, R. F., 306 W. Thornapple, Chevy Chase, Md.
*Gelstharp, Frederick, 1134 Park St., Tarentum, Pa.
General Ceramics Co. (Fred A. Whitaker), Keasbey, N. J.
General Color & Chemical Co. (Harry J. Keener), Sebring, Ohio
General Electric Co. (W. S. Kahlson), Lamp Dept., Pitney Glass Works, Nela Park, Cleveland, Ohio.
General Refractories Co. (Russell P. Heuer), 1600 Real Estate Trust Bldg., Philadelphia 7, Pa.
Gentry, Raymond, Alexander H. Kerr & Co., Inc., Box 535, Santa Ana, Calif.
†Gentsch, B. F., Oakfield, N. Y.
George, W. S., Pottery Co. (W. S. George), East Palestine, Ohio
George, W. S., W. S. George Pottery Co., East Palestine, Ohio
Georgia Kaolin Co. (Wharton Jackson), 433 N. Broad St., Elizabeth 3, N. J.
†Gerber, Albert C., 408 W. Walnut St., Robinson, Ill.
Gerber, Max, 232 N. Clark St., Section 1, Chicago 1, Ill.
Gerstenschlager, V., Jr., Babcock & Wilcox Co., Augusta, Ga.
†Gerster, C. W., 19 Forsyth Place, East Liverpool, Ohio
Gesner, M. A., 129 Sherwood Rd., Ridgewood, N. J.
Ghering, Leonard G., Box 847, Butler, Pa.
Gibbs, A. E., 1000 Widener Bldg., Philadelphia, Pa.
Gibbs, Peter W. (Student), 56, The Kingsway, Kingsway Park, Toronto, Ontario, Canada
†Gibson, R. L., 412 E. Winter Ave., New Castle, Pa.
Giehler, Fred J., Chicago Retort & Fire Brick Co., Ottawa, Ill.
Gieseke, Frans, Kockums Emaljerverk, Ronneby, Sweden
Gilbert, Wilfred, Reliance Firebrick & Pottery Co., Barakar, India
Giles, Kenneth B., 1327 Blue Ave., Zanesville, Ohio
Giles, Roy T., 331 Rebault Ave., Daytona Beach, Fla.
Gilfillan, J. M., Locke Insulator Corp., Box A, Baltimore, Md.
Gill, Francis D., Gill Glass & Fixture Co., 1330 Widener Bldg., Philadelphia 7, Pa.
Gill, John H., Gill Clay Pot Co., Muncie, Ind.
†Gill, Joseph W., 563 Hillside Ave., Elmhurst, Ill.
Gill, LaVerne N., American Radiator & Standard Sanitary Corp., Box 1866, Richmond, Calif.
Gillespie, H. M., 225 Broadway, New York 7, N. Y.
Gillinder Brothers, Inc. (J. Fletcher Gillinder), Port Jervis, N. Y.
Gillinder, James, Box 1007, Port Jervis, N. Y.
Gillinder, J. Fletcher, Gillinder Brothers, Inc., Port Jervis, N. Y.
Gimson, Joseph F., Worcester Royal Porcelain Co., Ltd., Royal Porcelain Works, Worcestershire, England
Gingold, Jacob, General Ceramics & Steatite Corp., Crows Mill Rd., Keasbey, N. J.
Girard, R. T., Works Lab., General Electric Co., Schenectady, N. Y.
†Gitter, A. Josephine, Apt. 6A, 2712 Wisconsin Ave., N.W. Washington 7, D. C.
Gitzen, Walter H., 1 Wesley Dr., Belleville, Ill.
Given, Conrad W., Great Lakes Steel Corp., Ecorse, Detroit 18, Mich.
Givens, Lt. Beverly L. (Student), Fort Church, R. I.
Gladding, McBean & Co. (F. A. Walsh), Lincoln, Placer County, Calif.
Gladding, Charles, Third & Keyes Sts., San Jose, Calif.
Glass Container Assn. (Victor L. Hall), 19 West 44th St., New York 18, N. Y.
Glaze, Francis W., 4100 Gallatin St., Hyattsville, Md.
Gleason-Tiebout Glass Co. (C. H. Tiebout), 59 54th St., Maspeth, N. Y.
Glenboig Union Fireclay Co., Ltd. (Alexander McKendrick), The Laboratory Star Works, Glenboig, Lanarkshire, Scotland
Glenshaw Glass Co., Inc. (George W. Meyer), Glenshaw, Pa.
Gleuck, M. A., Research Lab., 35th and Olive Sts., Kansas City, Mo.
Globe Brick Co. (S. C. Porter), East Liverpool, Ohio
Glossbrenner, D. I., R. D. 12, Box 261, Indianapolis, Ind.
Glover, William S., Westinghouse Electric & Mfg. Co., Glass Plant, Fairmont, W. Va.
Goddard, W. T., Box 428, Hamilton, Ontario, Canada
Godejohn, W. F., Laclede-Christy Clay Products Co., 1711 Ambassador Bldg., St. Louis, Mo.
Goetchius, Don R., 4150 East 56th St., Cleveland, Ohio
Goin, Lt. (jg) Fred L., New York, N. Y.
Goldberg, Mrs. Helen (Student), 2190 Grand Concourse, New York 57, N. Y.
Goldberg, Jacob (Student), 1589 President St., Brooklyn, N. Y.
Goldin, Joseph, Detroit, Mich.
Goldscheider Everlast Corp. (W. F. Goldscheider), 280 Third St., Trenton 10, N. J.
Goldscheider, W. F., Goldscheider Everlast Corp., 280 Third St., Trenton 10, N. J.
Goldschmidt, Rodolfo A., 3a Calle Oriente 3, San Salvador, El Salvador
Goldsmith, Julian R., 164 Pine St., Corning, N. Y.
Gómez, Salvador Odriozola, Fabrica de Ladrillos Industriales y Refractarios, S. A., Apartado 390, Monterrey, N. L., Mexico
Gonder, Lawton, Gonder Ceramic Arts, Inc., Zanesville, Ohio
Goodman, Gilbert, 116 West 47th St., Bayonne, N. J.
Goodman, H. A., Dominion Fire Brick & Clay Product Co., Claybank, Saskatchewan, Canada
†Goodrich, Hobert R., 469 W. Oak St., Glendale 4, Calif.
Gormly, Alan L., Shrewsbury St., Holden, Mass.
†Gornall, Henry A., Box 222, Magnolia, Ohio
Gort, Walter A., 37 Highland Ave., Metuchen, N. J.
Gottlieb, Sidney, U. S. Bureau of Mines, College Park, Md.
Goudge, Lt. (jg) Carlton E. (Student), San Francisco, Calif.
*†Gould, Robert E., 28 Union St., Hamburg, N. Y.
*Grady, R. F., Sr., 6825 Mitchell Ave., St. Louis, Mo.
Grageda, Jose T. (Student), Apartado Postal 363, Guadalajara, Jalisco, Mexico
Graham, Robert P., 2091 California St., Apt. 126, Berkeley 3, Calif.
Graveling, W. J., Box 559, Laredo, Texas
Gray, William T., 15 West 4th St., Corning, N. Y.

Great Lakes Foundry Sand Co. (C. L. Cruikshank), 720 United Artists Bldg., Detroit, Mich.
Great Lakes Steel Corp. (Conrad W. Given), Ecorse, Detroit 18, Mich.
*†Greaves-Walker, A. F., Dept. of Ceramic Engr., Univ. of North Carolina, Raleigh Unit, Raleigh, N. C.
Green, A. P., Fire Brick Co. (R. S. Bradley), Research Dept., Mexico, Mo.
Green, Allen P., A. P. Green Fire Brick Co., Mexico, Mo.
Green, A. T., Mellor Labs., Stoke-on-Trent, England
†Green, John R., 405 Penn Ave., Pittsburgh, Pa.
Green, Richard V., Hawaiian Crafts, Inc., Paducah, Ky.
Green, Robert L., General Electric Co., Research Lab., Schenectady, N. Y.
†Green, Robert S., 18 S. Jefferson Rd., Mexico, Mo.
Greene, Charles H., 230 Chemung St., Corning, N. Y.
Greene, J. F., 1123 Pear St., Vineland, N. J.
Greenspan, Le Roy (Student), 3470 Cannon Place, New York 63, N. Y.
Greenstreet, Edward C., 323 Broadmoor Rd., Baltimore 12, Md.
Greeves, Russell G., 1122 Leader Bldg., Cleveland 14, Ohio
Greger, Herbert H., 4410 Macomb St., N. W., Washington 16, D. C.
*†Gregorius, J. S., Pittsburgh Plate Glass Co., Grant Bldg., Pittsburgh, Pa.
Gregory, G. S., Phoenix Glass Co., Monaca, Pa.
Greider, Harold W., Philip Carey Mfg. Co., Lockland, Cincinnati 15, Ohio
Griffith, Alfred P., 3937 Edgehill Dr., Los Angeles, Calif.
Griffith, James D. (Student), 314 W. Adams St., Clinton, Ill.
Griffith, R. E., E. J. Lavino and Co., 1528 Walnut St., Philadelphia 2, Pa.
Grigg, Paul E., Miller Dr., North Muskegon, Mich.
Grigorieff, Wladimir W., Lenox, Mass.
Grim, Ralph E., Illinois Geological Survey, Urbana, Ill.
Grindley Artware Mfg. Co. (A. K. Grindley), Box 166, Sebring, Ohio
Grindley, A. K., Grindley Artware Mfg. Co., Box 166, Sebring, Ohio
Grobb, F. S., Sternson Labs., Ltd., Brantford, Ontario, Canada
Grodsky, James W., 3412 S. Wakefield St., Fairlington, Arlington, Va.
Grossman, Harold, American Lead Pencil Co., Hoboken, N. J.
Grossman, Israel, Ednal Co., Inc., 95 Madison Ave., New York 16, N. Y.
Grossman, R. B., Southern California Gas Co., Box 3249, Terminal Annex, Los Angeles, Calif.
Grove, Thomas (Student), 22 Berkmans St., Worcester, Mass.
Gruver, Robert M. (Student), Dept. of Ceramics, Pennsylvania State College, State College, Pa.
Guardia, Jorge A. (Student), 108 E. John St., Champaign, Ill.
Guastavino, Rafael, 143 Awixa Ave., Bayshore, Long Island, N. Y.
Guenther, E. B., 16 Duncan Ave., Crafton, Pittsburgh 5, Pa.
Gulick, Capt. Chester, San Francisco, Calif.
Gunzenhauser, Adolf, 617 W. End Ave., New York 24, N. Y.
Gustafson, Dwight F., East 4217 22nd, Spokane 10, Wash.
Gustavsbergs, A. B., Fabriks, Intressenter, Gustavsberg, Stockholm, Sweden
Gustin, Jud A., 2140 East 82nd St., Chicago 17, Ill.
Guthrie, George, "Ochil," Harrow Rd., Sudbury Hill, Wembley, Middlesex, England
Gutman, Raymond T., Ohmite Mfg. Co., 4835 Flournoy St., Chicago 44, Ill.
Gutmann, Paul F., 5331 Nottingham Ave., St. Louis 9, Mo.
Guy, Thomas J., 660 Hanna Bldg., Cleveland, Ohio

Haaf, George J., 2703 Milton Ave., Solvay 9, N. Y.
Haag, Francis E., United Feldspar & Minerals Corp., 10 East 40th St., New York 16, N. Y.
Hackler, Lt. W. C. (Student), Fort McClellan, Ala.
Haeger Potteries, Inc. (E. H. Haeger), Dundee, Ill.
Haeger, E. H., Haeger Potteries, Inc., Dundee, Ill.
Haff, R. S., Jr., 19 Willard St., Hartford 5, Conn.
Hafner, Harold C., 17 Barnard St., Rochester 12, N. Y.
*†Hagar, Donald, Box 328, Zanesville, Ohio
Hagedorn, Alwin J. E., John W. Higman Co., 24 State St., New York, N. Y.
Hagerman, Capt. Robert S., Fort Sill, Okla.
Hahner, Clarence H., National Bureau of Standards, Washington, D. C.
†Haldy, Norman L., 441 Stewart Ave., Columbus, Ohio
Hale, Edwin, 1139 National Rd., Wheeling, W. Va.
Haley, Kenneth R., 636 Fairmont St., Greensburg, Pa.
Hall China Co. (M. W. Thompson), East Liverpool, Ohio
Hall, Clyde W., United Clay Mines Corp., Trenton 6, N. J.
Hall, Everson, Park Blvd., East Liverpool, Ohio
*Hall, F. P., R. D. 2, Navarino, Syracuse, N. Y.
Hall, Henry, "Ravenshoe," Kingland Rd., Poole, England
Hall, James L., Metallurgical Dept., American Brake Shoe Co., Mahwah, N. J.
Hall, John T., Park Blvd., East Liverpool, Ohio
Hall, Morris P., 3218 Shadyway Dr., Pittsburgh 10, Pa.
Hall, Victor L., Glass Container Assn., 19 West 44th St., New York 18, N. Y.
Haller, P., 106, High Storrs Rd., Sheffield 11, England
Halloin, William G., 1218 Broadview Blvd., Brackenridge, Pa.
Halpern, Allan S. (Student), 54 Huntington Terrace, Newark 8, N. J.
Hamaker, M. L., Columbia Fire Brick Co., First National Bank Bldg., Canton, Ohio
Hamer, Donald W. (Student), Univ. of Illinois, Urbana, Ill.
Hamilton, D. C., Bartlett-Collins Co., Sapulpa, Okla.
Hampden Grinding Wheel Co. (G. S. Emerson), 118 Fisk Ave., Springfield 7, Mass.
Hancock Brick & Tile Co. (J. Leo Child), Findlay, Ohio
Handwerk, Joseph H., 725 Oak St., Flint, Mich.
Hanes, John G., Republic Steel Corp., Warren, Ohio
Haney, H. L., Harshaw Chemical Co., 2424 Enterprise St., Los Angeles, Calif.
Hanks, Charles F., Jr., 809 S. Mercer Ave., Bloomington, Ill.
Hanley Co. (J. Clair Peck), Summerville, Pa.
†Hanna, H. H., Pittsburgh Plate Glass Co., Crystal City, Mo.
Hanna, Henry N., Clinchfield Sand & Feldspar Corp., 618 Mercantile Trust Bldg., Baltimore 2, Md.
Hannah, E. R., 620 E. Jackson St., Mexico, Mo.
Hanovia Chemical & Mfg. Co. (W. Riehl), Chestnut St. & N.J.R.R. Ave., Newark 5, N. J.
†Hansard, W. Carey, 1054 McLynn Ave., N. E., Atlanta, Ga.
Hansen, I. A., Fords Porcelain Works, Perth Amboy, N. J.
*Hansen, J. E., Ferro Enamel Corp., Forbes Rd., Bedford, Ohio
Hanson, G. G., 4436 N. Maplewood Ave., Chicago 25, Ill.
Hanson, J. R., Diamond Glass Co., Royersford, Pa.
Harbison-Walker Refractories Co. (Kenneth Seaver), 1800 Farmers Bank Bldg., Pittsburgh 22, Pa.
†Harcourt, Edward L., Alliance Clay Products Co., Alliance, Ohio
Hardenbrook, Roy W., 301 Wellington Ave., Rochester 11, N. Y.
Harder, Charles M., Alfred Univ., Alfred, N. Y.
Harding, Russell J., Box 496, Ottawa, Ill.
Hardinge Co., Inc. (Harlowe Hardinge), York, Pa.
Hardinge, Harlowe, Hardinge Co., Inc., York, Pa.
†Hardy, R. G., Ludowici-Celadon Co., New Lexington, Ohio
Harker Pottery Co. (Robert E. Boyce), East Liverpool, Ohio
Harley, Ted H. (Student), 2321 Tremont Rd., Columbus, Ohio
*Harman, C. G., 204 Ceramics Bldg., Univ. of Illinois, Urbana, Ill.
Harnish, John D., Jr., 401 N. Chestnut St., Derry, Pa.

Harper, Roderick L., Harper Electric Furnace Corp., Niagara Falls, N. Y.
†Harr, William J., 11 Fletcher Ave., Mount Vernon, N. Y.
Harrington, Henry W., 757 Chenango St., Binghamton 6, N. Y.
Harris, Robert W., Dillsboro, N. C.
Harris, S. C., E. I. du Pont de Nemours & Co., Inc., Electrochemicals Dept., Wilmington, Del.
Harris, William J., Crossley Machine Co., Trenton 9, N. J.
Harrison, Harold C., Westinghouse Electric & Mfg. Co., Central Engr. Lab. & Stds. 11–L–47, East Pittsburgh, Pa.
*Harrison, W. N., National Bureau of Standards, 151 Industrial Bldg., Washington, D. C.
Harshaw Chemical Co. (D. G. Pierce), Intelligence Service Div., 1945 East 97th St., Cleveland, Ohio
Hartford-Empire Co. (F. Goodwin Smith), Box 1620, Hartford, Conn.
*Hartford, Frank M., Allied Argentina, S. A. de Ingenieria y Ceramica, Corrientes 378, Buenos Aires, Argentina
Harth, P. E., 835 Oleta Dr., Clayton, Mo.
Hartman, Francis H., 226 Polson Ave., Winnipeg, Manitoba, Canada
Hartshorn, T. D., A. J. Lindemann & Hoverson Co., Milwaukee 7, Wis.
Harty, William A., Exolon Co., Tonawanda, N. Y.
Harvey, Lt. A. M., Jr., Roanoke-Webster Brick Co., Box 1001, Roanoke 5, Va.
Harvey, E. M., North State Pyrophyllite Co., Inc., Pomona, N. C.
Harvey, Edwin T., 314 W. McPike St., Vandalia, Mo.
*†Harvey, F. A., Harbison-Walker Refractories Co., 1800 Farmers Bank Bldg., Pittsburgh 22, Pa.
Hasselbach, William, Libbey-Owens-Ford Glass Co., 1701 E. Broadway, Toledo 5, Ohio
Hastings, Francis H., 16 Forest St., Hartford, Conn.
Hatch, J. W., 713 N. Main St., Abingdon, Ill.
Hatch, Robert A., Corning Glass Works, Corning, N. Y.
Hathaway, A. J. (Student), 8636 Champlain Ave., Niagara Falls, N. Y.
Hathaway, Isaac, Box 493, Tuskegee Institute, Ala.
Hauser, Ernst A., Massachusetts Inst. of Tech., Cambridge 39, Mass.
Hawk, Elwin A., Hawk Labs., R. D. 1, East Rochester, Ohio
Hawke, C. E., Carborundum Co., Perth Amboy, N. J.
Hawkins, George W., Isolantite, Inc., 343 Cortlandt St., Belleville 9, N. J.
Hawkinson, John L., 211 Girard Ave., Hartford, Conn.
Hawks, Ralph L. (Student), 3932 North 31st Street, Tacoma 7, Wash.
Haws Refractories Co. (E. E. Slick), 407 Main St., Johnstown, Pa.
Hay, R. G., Central Silica Co., Zanesville, Ohio
Hazel-Atlas Glass Co. (Francis C. Flint), 319 S. Main St., Washington, Pa.
†Hazen, E. J., R. D. 2, Ford City, Pa.
Healy, James H. (Student), Univ. of Illinois, Urbana, Ill.
Heaslet, James, Jr., "Blairlea," Stobswood, Morpeth, Northumberland, England
*†Heath, Frederick Jr., 2221 Central Grove Ave., Toledo, Ohio
Hebenstreit, W. H., Royal China, Inc., Sebring, Ohio
Heck, F. G., E. J. Lavino and Co., 1528 Walnut St., Philadelphia 2, Pa.
Hedden, Walter A., 25 Elm St., Dalton, Mass.
Hedquist, Alfred J., 620 Louisiana Ave., Chester, W. Va.
Heiligman, H. A., E. J. Lavino and Co., Box 29, Norristown, Pa.
*Heindl, Raymond A., 4917 43rd St., N. W., Washington 16, D. C.
Heisey, A. H. & Co. (T. C. Heisey), Newark, Ohio
Heisey, T. C., A. H. Heisey & Co., Newark, Ohio
Heistand, Elza F., Gill Clay Pot Co., Muncie, Ind.
Hellman, Stanley (Student), 882 Vedado Way, N. E., Atlanta, Ga.
Hellmers, Henry T., 141 Marks Ave., Lancaster, Ohio
*†Helser, Perry D., 394 S. Lexington Ave., White Plains, N. Y.
Helton, B. L., Jr., 940 Hickman Rd., Augusta, Ga.
Helz, Armin W., Gaithersburg, Md.
Hemphill, R. W., Colonial Insulator Co., 973 Grant St., Akron 11, Ohio
Hemsteger, Samuel E., 27180 Wellington Rd., Franklin, Mich.
†Henderson, Chester E., 430 11th St., Oakmont, Pa.
*Henderson, Frederick C., Royal China, Inc., Sebring, Ohio
*Henderson, H. B., Box 12, East Liverpool, Ohio
Henderson, John H. (Student), 4714 19th Ave., N. E., Seattle 5, Wash.
Henderson, L. A., W. A. Riddell Co., Bucyrus, Ohio
Hendren, Robert R., 618 Weldon St., Latrobe, Pa.
†Henry, Edward C., 723 Jackson St., State College, Pa.
*Henry, Frank R., Simonds Worden White Co., Dayton 7, Ohio
Henry, Kenneth M., Kimble Glass Co., Vineland, N. J.
*†Hepplewhite, J. W., 241 Pennsylvania Ave., East Liverpool, Ohio
Herbert, John S., 174 Third Ave., N., Nashville, Tenn.
Herger, Howard C., Pierce Glass Co., Port Allegany, Pa.
Herman, Adalbert, Distillers Corp., Ltd., 1430 Peel St., Montreal, Quebec, Canada
Hermann, Max, 239 Ocean Ave., Brooklyn, N. Y.
†Herold, John F., Tide Water Associated Oil Co., Box 811, Ventura, Calif.
*†Herold, Paul G., Missouri School of Mines, Rolla, Mo.
Hertzell, E. A., 1104 N. Walnut St., Dover, Ohio
Hess, F. B., Brockway Glass Co., Inc., Brockway, Pa.
Hess, Henry W., 614 Stratford Place, Toledo 10, Ohio
Hess, Ralph F., Jr., 510 Filbert St., Curwensville, Pa.
Hess, R. F., North American Refractories Co., Cleveland, Ohio
Hess, R. Jones, 309 S. Centre St., Philipsburg, Pa.
Hess, Robert E., 1004 Elwood St., Middletown, Ohio
Hess, Robert L. (Student), Dept. of Ceramics, Pennsylvania State College, State College, Pa.
Hesse, Helen L., 652 N. Columbus Ave., Glendale 3, Calif.
*Hettinger, E. L., 1325 Mineral Spring Rd., Reading, Pa.
Heuer, Russell P., General Refractories Co., 1600 Real Estate Trust Bldg., Philadelphia 7, Pa.
Heussner, Carl E., 552 Brookside Dr., Birmingham, Mich.
*†Hewitt, L. C., 4705 Ridgewood, St. Louis, Mo.
Heythum, Antonin, Industrial Design Section, California Inst. of Tech., Pasadena, Calif.
Higgins, Waldo W., 5415 N. Shoreland Ave., Milwaukee, Wis.
Higman, John W., Co. (Robert J. Stone), 24 State St., New York 18, N. Y.
Hilgenberg, Carl R., Carr-Lowrey Glass Co., Box 356, Baltimore 3, Md.
*†Hill, E. C., General Grinding Wheel Corp., Clementine, Thompson and Mercer Sts., Philadelphia 34, Pa.
Hill, Vincent J. D., 34, Nightingale Rd., Carshalton, Surrey, England
Hillier, C. G., Winstone's Roofing Tile Works, Ltd., Taumarunui, North Island, New Zealand
Hinckley, Arthur T., Oldbury Electro-Chemical Co., Niagara Falls, N. Y.
Hind, Stanley, "The Mount," Etruria Rd., Basford, Stoke-on-Trent, England
Hines, Ronald W., 1221 Highland St., Columbus 1, Ohio
Hirssig, Carl F., 4554 Westway, Toledo, Ohio
Hitchins, R. A., National Refractories Co., Inc., 1520 Locust St., Philadelphia 2, Pa.
†Hite, Earl E., R. D. 1, Toronto, Ohio
†Hite, Everett C., 813 23rd St., N. W., Canton, Ohio
Hoare, H. A., Mansfield Sanitary Pottery, Inc., Perrysville, Ohio
Hobert, Leroy F., 318 Huron Ave., Sandusky, Ohio
Hocking, William J., 1612 Pennsylvania Ave., East Liverpool, Ohio
*Hodek, F. E., Jr., 2700 N. Karlov Ave., Chicago 39, Ill.
Hodson, George N., 58, Park Rd., Loughborough, England
Hoehl, Joseph W., Wolverine Porcelain Enameling Co., 3350 Scotten Ave., Detroit 10, Mich.
Hoehn, Charles J. P., 18th & Florida Sts., San Francisco, Calif.

Hoeppner, W. L., Hayward Optical Glass Co., Box 26, Maywood, Calif.
Hoffman, Lewis C. (Student), Univ. of Illinois, Urbana, Ill.
Hogendobler, H. R., Owens-Corning Fiberglas Corp., Toledo 1, Ohio
Hogenson, William, Chicago Vitreous Enamel Product Co., 1407 South 55th Court, Cicero, Ill.
Hohmann, Frederick R., 712 10th St., Oakmont, Pa.
Holberg, A. S., Alabama Clay Products Co., 830–835 Martin Bldg., Birmingham, Ala.
Holland, J. B., Port Hope Sanitary Mfg. Co., Ltd., Port Hope, Ontario, Canada.
Holland, Job, Box 22, Sheffield, England
*†Holmes, Dean M. E., N. Y. State College of Ceramics, Alfred, N. Y.
Holmgren, David E. (Student), Elizabeth Manor, Apt. 219, West Chester Pike and Brief Ave., Upper Darby, Philadelphia, Pa.
Holophane Co., Inc. (Charles Franck), 342 Madison Ave., New York 17, N. Y.
†Holscher, H. H., Owens-Illinois Glass Co., General Research Lab., 1700 Westwood Ave., Toledo 1, Ohio
Hommel, Ernest M., 1520 Valmont St., Pittsburgh, Pa.
Hommel, O., Co. (E. M. Hommel), 209 4th Ave., Pittsburgh 30, Pa.
*Hood, B. Mifflin, Mifflin Hood Brick Co., Daisy, Tenn.
Hood, Harrison P., 83 East 4th St., Corning, N. Y.
Hoover, Charles H., 3413 Ramona Ave., Baltimore 13, Md.
*†Horak, William, Hartford-Empire Co., Hartford 1, Conn.
*Horning, Roy A., Armstrong Cork Co., Lancaster, Pa.
†Hornung, Martin R., 140 Sheridan Ave., New Castle, Pa.
Hossenlopp, Arthur M., 28 Kendall Ave., Maplewood, N. J.
*†Hostetter, J. C., Mississippi Glass Co., Main and Angelica Sts., St. Louis 7, Mo.
Hostetter, John R., Zenith Optical Co., Huntington, W. Va.
*Hottinger, A. F. (Life), 927 S. Monroe Ave., Green Bay, Wis.
Hough, Albert W., Box 480, Columbia, S. C.
Houghton, Amory, The Knoll, Corning, N. Y.
Housman, George S., 208 W. Fornance St., Norristown, Pa.
Houze, Armand L., Jr., L. J. Houze Convex Glass Co., Point Marion, Pa.
Houze, L. J., Convex Glass Co. (Roger J. Houze), Point Marion, Pa.
Houze, Roger J., L. J. Houze Convex Glass Co., Point Marion, Pa.
*Howat, Walter L., 85 Hopping Ave., Staten Island 7, N. Y.
Howatt, Glenn, 15 Cliffwood Place, Metuchen, N. J.
Hower, Lawrence D., Jr., 3926 Beechwood Blvd., Pittsburgh 17, Pa.
Hower, Robert S., R. D. 1, Osborn, Ohio
Howie, John R., Templetonburn, Kilmarnock, Scotland
Howie, Thomas W., United Steel Co., Ltd., Central Research Dept., Stocksbridge, near Sheffield, England
Hoyet, Eugene, Box 213, Natrona Heights, Pa.
Hoyt, Philip S., Van Horn, Texas
Hubbard, Arthur E., 13 Clifford Rd., Sharrow, Sheffield, England
Hubbard, C. H., Alexander H. Kerr & Co., Inc., Sand Springs, Okla.
Huber, Harold V., 691 S. Harvard Blvd., Los Angeles 5, Calif.
Hubler, William G., Nepheline Products, Ltd., Lakefield, Ontario, Canada
Hudson, Charles J., Norton Co., Worcester, Mass.
Hug, William O., Lake Desolation, Middle Grove, N. Y.
Hughes, Calvin S., Arketex Ceramic Corp., Brazil, Ind.
Hughes, Chester A., 3105 South 3rd St., Ironton, Ohio
Hughes, Lt. George B., 323 Washington St., Cedar Falls, Iowa
†Hughes, Walter M., 534 Putnam Ave., Zanesville, Ohio
Hugill, William, Langham House, Fields Rd., Alsager, England
Hull, A. E., Pottery Co. (Gerald F. Watts), Crooksville, Ohio
*Hull, Walter A., Box 367, Norris, Tenn.
Hults, Eugene A., 1005 Chester St., Bristol, Va.
Hummel, D. B., Polaroid Corp., 211 Massachusetts Ave., Cambridge, Mass.
Hummel, Floyd A., 155 Seneca St., Box 308, Corning, N. Y.
Hummel, Richard, 615 Olympia Rd., Pittsburgh 11, Pa.
Hummel, Roy, B. G. Corp., Broad Ave. & Shaler Blvd., Ridgefield, N. J.
Humphrey, John R., Missouri School of Mines, Rolla, Mo.
Humphrey, Kenneth F. (Student), 726 12th St., Saskatoon, Saskatchewan, Canada
Humphreys, R. D., Mississippi Glass Co., 200 Fifth Ave., New York 10, N. Y.
Hunsicker, Harold W., 1649 Elberon Ave., East Cleveland 12, Ohio
Hunt, Ercel B., 1209 E. Promenade, Mexico, Mo.
Hunt, George, General Steel Wares, Ltd., 199 River St., Toronto, Ontario, Canada
Hunt, Herbert J., Kimble Glass Co., Vineland, N. J.
†Hunt, John F., Orefraction, Inc., 7505 Mead St., Pittsburgh 8, Pa.
†Hunt, M. H., Porcelain Products, Inc., Parkersburg, W. Va.
Hunter, Charles E., 2724 E. Magnolia Ave., Knoxville, Tenn.
Hunter, Richard S., National Bureau of Standards, Washington 25, D. C.
Hunting, Everett C., Engr. Dept., Westinghouse Electric & Mfg. Co., Lamp Div., Bloomfield, N. J.
Huppert, Paul A., Lisk Mfg. Co., Canandaigua, N. Y.
Hurlbut, Francis J., "High Trees," Eccleston Park, Prescot, Lancashire, England
*†Hursh, Ralph K., Univ. of Illinois, Urbana, Ill.
Hurst, Capt. Thomas L., C. W. S., Research & Development Div., Edgewood Arsenal, Md.
Hutchins, Otis, Carborundum Co., Niagara Falls, N. Y.
Hutchison, Clark, 851 N. Clay St., Frankfort, Ind.
Hutchison, Clyde B., Box 225, Sandersville, Ga.
†Hutchison, R. C., R. D. 1, Easton Ave., Bethlehem, Pa.
Hutt, Glenn A., Ferro Enamel Corp., 4150 East 56th St., Cleveland, Ohio
Hutt, Gordon M., Asst. Development Commissioner, Canadian Pacific Ry., Winnipeg, Manitoba, Canada
†Hyde, Collin, 4741 Fremont Ave., S., Minneapolis, Minn.
Hyland, J. A., Pacific Coast Borax Co., 2295 Lumber St., Chicago 16, Ill.
Hyslop, Joseph F., "Dromore," Major's Loan, Falkirk, Scotland

Ideal Tooth, Inc. (Martin Myerson), Cambridge 39, Mass.
Iles, Ramon, 68 Cottage St., Easthampton, Mass.
Iliff, John W., 15401 Richmond Place, East Cleveland, Ohio
Illing, Arno M., 203 Hartwell Ave., Cincinnati 15, Ohio
Illinois Clay Products Co. (O. L. Jones), 214 Barber Bldg., Joliet, Ill.
Illinois Water Treatment Co. (W. S. Morrison), Rockford, Ill.
Imperial Glass Corp. (C. J. Uhrmann), Bellaire, Ohio
Indiana Glass Co. (Charles L. Gaunt), Dunkirk, Ind.
Industrial Ceramic Products, Inc. (W. E. Cramer), 965 W. Fifth Ave., Columbus 8, Ohio
Industrial Filter Sack Co. (Hugh Nile), Wellsville, Ohio
Ingham, David M. (Student), 58 E. Main St., Ripley, N. Y.
Ingle, Henry W., 35 Giddings Ave., Windsor, Conn.
Ingram-Richardson Mfg. Co. of Indiana, Inc. (C. P. Scripture), Frankfort, Ind.
Inland Firebrick Co. (George S. Davies), 3120 Berea Rd., Cleveland 11, Ohio
†Innes, David H., Box F, Berlin, N. J.
*Insley, Herbert, Dept. of Earth Sciences, School of Mineral Ind., Pennsylvania State College, State College, Pa.
International Clay Machinery Co. (R. H. McElroy), 1145 Bolander Ave., Dayton, Ohio

International Smelting & Refining Co. (W. M. Weathers), 577 Malvern Rd., Akron 3, Ohio
Ireland, John, International Tin Research & Development Council, Fraser Rd., Greenfold, Middlesex, England
Ironton Fire Brick Co. (E. F. Myers), 707 Carolina Life Bldg., Box 1324, Columbia, S. C.
†Irvine, George C., 2251 Orchard Ave., Niagara Falls, Ontario, Canada
Irwin, Dewitt D., Potters Supply Co., East Liverpool, Ohio
Irwin, J. P., Arthur G. McKee & Co., 2300 Chester Ave., Cleveland 1, Ohio
Irwin, Philip P., Box 320, Manor Lane, East Liverpool, Ohio
Irwin, William W., Potters Supply Co., East Liverpool, Ohio
Isenhour, C. W., Jr., 601 W. Innes St., Salisbury, N. C.
*Isenhour, John H., 215 Confederate Ave., Salisbury, N. C.
Isolantite, Inc. (George W. Hawkins), 343 Cortlandt St., Belleville 9, N. J.

†Jackson, A. Curtis, 464 Eastmoor Blvd., Columbus 9, Ohio
Jackson, James, Ashgrove, Bothwell, Lanarkshire, Scotland
Jackson, L. P., 1960 E. Milwaukee Ave., Detroit 11, Mich.
Jackson, Wharton, Georgia Kaolin Co., Dry Branch, Ga.
Jacobi, James H. (Student), Molino, Fla.
Jacobs, Charles W. F., Box 95, Alfred, N. Y.
Jacobs, Louis J., Ramtite Co., 2563 West 18th St., Chicago 8, Ill.
Jacobs, Richard A., 731 Benoni Ave., Fairmont, W. Va.
Jacobson, Albert, 29 West 8th St., New York 11, N. Y.
Jacoby, Clarence A., Radio Corp. of America, R.C.A. Victor Div., 415 S. Fifth St., Harrison, N. J.
Jahns, Alfred H., 6033 Wellesley Way, Seattle 5, Wash.
Janatka, Richard G., Harris Clay Co., Spruce Pine, N. C.
Jansma, Frank, Box 519, Washington, Pa.
Jarrett, LeGrand, Westinghouse Electric & Mfg. Co., Glass Plant, Fairmont, W. Va.
Jeffery, Benjamin A., Ceramic Div., Champion Spark Plug Co., 8525 Butler Ave., Detroit, Mich.
Jeffery, Benjamin D., 315 Hendrie Blvd., Royal Oak, Mich.
*Jeffery, Joseph A., Champion Spark Plug Co., Ceramic Div., Butler Ave. and Grand Trunk R.R., Detroit 11, Mich.
Jeffrey, G. H., R. D. 1, Pines Lake, Paterson, N. J.
Jenkins, Howard F., 235 N. 2nd St., Jeannette, Pa.
Jenks, C. E., W. S. Tyler Co., 3615 Superior Ave., N. E., Cleveland 14, Ohio
*Jeppson, George N., Norton Co., Worcester 6, Mass.
Jewart, Charles N., Oxford Terrace, Locksley Park, R. D. 1, Hamburg, N. Y.
Jobling-Purser, Ernest J., James A. Jobling & Co., Ltd., Wear Glass Works, Sunderland, England
Johns-Manville Sales Corp. (J. C. Crawford, Jr.), 22 East 40th St., New York 16, N. Y.
Johnson Glass Co. (Willam Garland), 5248 Elston Ave., Chicago 30, Ill.
Johnson, A. B., 41 Elm St., Apt. 101, Elizabeth 3, N. J.
Johnson, Andrew L., Massachusetts Inst. of Tech., Cambridge 39, Mass.
Johnson, Arnold G., 810 Dixie Highway, Rossford, Ohio
Johnson, Ernest W., 971 Mountain Ave., Westfield, N. J.
Johnson, F. G., Messrs. Johnson Brothers, Hanley, Staffordshire, England
Johnson, Gordon H. (Student), 106 E. Chalmers, Champaign, Ill.
Johnson, Harold C., 198 E. Third St., Corning, N. Y.
Johnson, J. A., Service Engrs., Ltd., Leek New Rd., Cobridge, Burslem, Stoke-on-Trent, England
Johnson, Peter (Student), 106 Queensberry St., Boston, Mass.
Johnston, H. J. C., Leeds Fire Clay Co., Wortley, Leeds, England
Jones Metal Products Co., West Lafayette, Ohio
†Jones, Edmund, Jr., 8153 S. Evans Ave., Chicago 19, Ill.
Jones, Frank L., Bausch & Lomb Optical Co., Rochester, N. Y.
Jones, George A. (Student), 437 Kinsley St., Sherrill, N. Y.
Jones, 1st Lt. Harlow G., Hammer Field, Fresno, Calif.
Jones, Maynard J., 267 Colwick Rd., Rochester 11, N. Y.
Jones, O. L., Illinois Clay Products Co., 214 Barber Bldg., Joliet, Ill.
Jones, Richard E., Pittsburgh Plate Glass Co., Research Lab., Creighton, Pa.
Jones, Rodney A., c/o Mrs. Nina Dennis, Jasper, N. Y.
Jones, Thorold G., E. 4. Treforest Trading Estate, near Pontypridd, Glamorganshire, South Wales
Jordan, John W., Mellon Inst., Pittsburgh 13, Pa.
Jordan, Roy E., Jr., Atlantic Tile Mfg. Co., Matawan, N. J.
Jova Brick Works (J. L. Jova), Roseton, N. Y.
Jova, J. L., Jova Brick Works, Roseton, N. Y.
Judd, A. C., Portsmouth Clay Products Co., Portsmouth, Ohio

Kadie, Carl H., Box 5730, Bethesda 14, Md.
Kaeppel, Herbert V., 59 E. Van Buren St., Chicago 5, Ill.
Kahlson, W. S., General Electric Co., Lamp Dept., Pitney Glass Works, Nela Park, Cleveland, Ohio
Kallstedt, C. H., Western United Gas & Electric Co., 50 Fox St., Aurora, Ill.
Kantner, Ogden A., 562 Cleardale Ave., Trenton 8, N. J.
Kantor, Neil I. (Student), 225 Parkside Ave., Brooklyn 26, N. Y.
Kaplowitz, Fred (Student), 120 Lake St., Spring Valley, N. Y.
Kapner, Charles, Bellaire Enamel Co., Bellaire, Ohio
Karpel, Jewell (Student), N. Y. State College of Ceramics, Alfred, N. Y.
*†Kauffman, John R., Allied Engr. Co., 29 Highland Dr., Milltown, N. J.
*†Kautz, Karl, 754 Rotch Ave., N. E., Massillon, Ohio
Kay, William T., 10711 20th Ave., N. E., Seattle, Wash.
Kayser, Julius A., 1711 Ambassador Bldg., St. Louis, Mo.
Keaney, Joe C., 855 Academy Place, Pittsburgh 16, Pa.
Kebler, Leonard, Ward Leonard Electric Co., Mount Vernon, N. Y.
Keehn, Clarence G., Lisk Mfg. Co., Canandaigua, N. Y.
Keener, Harry J., General Color & Chemical Co., Sebring, Ohio
Keith, Gordon C., 49 Turner Rd., Toronto 10, Ontario, Canada
Keith, Wendell P., Ceramic Dept., Massachusetts Inst. of Tech., Cambridge, Mass.
Keller, W. D., 203 Swallow Hall, Univ. of Missouri, Columbia, Mo.
Kellogg, George W. (Student), Adams Center, N. Y.
Kelly, Joseph F., 301 Braddock Ave., Lansdowne, Pa.
*Kelsey, V. V., Dominion Minerals, Inc., Shoreham Bldg., Washington 5, D. C.
†Kelting, Richard P., 624 Islington St., Toledo, Ohio
†Kempf, William C., 28 Homer Place, Metuchen, N. J.
†Kenagy, William L., Huntingdon Valley, Pa.
Kennaday, Clinton R., R. D. 4, New Castle, Pa.
†Kent, G. G., Square D Co., Peru, Ind.
†Kent, N. Johnson, Johns-Manville Sales Corp., 22 East 40th St., New York 16, N. Y.
Kentucky Clay Mining Co. (W. J. Watkins), Mayfield, Ky.
Kentucky-Tennessee Clay Co. (R. C. Meeker), 807 City Savings Bldg., Alliance, Ohio
Kenworthy, Orville O., B. F. Drakenfeld & Co., Inc., 45–47 Park Place, New York, N. Y.
Kern, Edward F., R. D. 2, Argyle, Washington County, N. Y.
Kerper, Matthew (Student), 2018 Victor St., St. Louis, Mo.
Kerr, Alexander H., & Co., Inc. (C. H. Hubbard), Sand Springs, Okla.
*Kerr, Charles H., 1501 N. Rhodes St., Apt. 2, Arlington, Va.
*†Kerr, W. R., Armstrong Cork Co., 27th St. Plant, Beaver Falls, Pa.

Kershner, William (Student), c/o Mrs. E. B. Kershner, 117 South 14th St., Olean, N. Y.
Kiburz, Walter H., Jr. (Student), 1007 Main St., Rolla, Mo.
†Kidner, Vernon H., 473 Marlin Dr., Pittsburgh 16, Pa.
Kidwell, J. F., 4026 Beechwood Blvd., Pittsburgh, Pa.
Kiehl, Harry R., 223 Chemung St., Corning, N. Y.
Kilcoyne, John R. (Student), Alameda, Saskatchewan, Canada
Kimball, Claude N., Jr. (Student), Enfield, N. C.
Kimble Glass Co. (M. A. Eddy), Vineland, N. J.
Kimble, Herman K., Kimble Glass Co., Vineland, N. J.
Kimes, Arthur W., *National Glass Budget*, Rms. 405–6, 313 Sixth Ave., Pittsburgh 22, Pa.
†King, Burnham W., Jr., Harshaw Chemical Co., 1945 East 97th St., Cleveland 6, Ohio
King, Charles B., 127 E. First St., Corning, N. Y.
King, Maxon H., Box 368, East Liverpool, Ohio
*†King, R. M., Lord Hall, Ohio State Univ., Columbus 10, Ohio
King, Walter F., 4816 A St., Philadelphia 20, Pa.
Kingsbury, Howard F., 509 Vallamont Dr., Williamsport 16, Pa.
Kingsley, Charles B., Mississippi Glass Co., Floreffe, Pa.
*Kinzie, C. J., Box 821, Falls Sta., Niagara Falls, N. Y.
Kirchner, Alfred M., 758 Frick Annex Bldg., Pittsburgh 19, Pa.
Kirk, Charles L., 486 Carnegie Dr., Pittsburgh 16, Pa.
Kirkendale, George A., Dept. of Mines, Industrial Minerals Div., Lydia St., Ottawa, Ontario, Canada
*Kirkpatrick, F. A., 466 Columbia Ave., Pomona, Calif.
Kirsch, Alphonse J., 149 Manhattan Ave., New York, N. Y.
Kitaigorodsky, J. J., Petrovsky Blvd., 4–6 App. 4, Moscow, U. S. S. R.
*Klein, A. Albert, Norton Co., Worcester, Mass.
Kleinfeldt, H. F., Abbé Engr. Co., 50 Church St., New York 7, N. Y.
Klekotka, Joseph, 3601 Reed St., Philadelphia 46, Pa.
*Kleymeyer, Henry C., Standard Brick & Tile Corp., Evansville 19, Ind.
Kline, Hugh L., 4107 Winchester Rd., Louisville 7, Ky.
*†Klinefelter, T. A., Southern Expt. Sta., U. S. Bureau of Mines, Tuscaloosa, Ala.
Kling, Jackson D., Zenith Optical Co., 832 Fifth Ave., Huntington 19, W. Va.
Klocke, Edward J., H. C. Spinks Clay Co., Box 256, Newport, Ky.
Knapp, Thomas E. (Student), 430 E. Winter Ave., New Castle, Pa.
†Knapp, William J., 15 Blake St., Belmont, Mass.
Knauft, Robert W., Charles Taylor Sons Co., Cincinnati 14, Ohio
†Knecht, Albert O., 2210 E. Main St., Springfield, Ohio
Knight, E. H., Maurice A. Knight Sons' Co., Crooksville, Ohio
*Knight, Frank P., Jr., Christmas, via Winkelman, Ariz.
Knight, Maurice A., "Knight-Ware" (M. A. Knight, Jr.), Box 111, Akron 9, Ohio
Knight, M. A., Jr., Maurice A. Knight, "Knight-Ware," Box 111, Akron 9, Ohio
Knight, Mellen A., Preston Labs., Box 847, Butler, Pa.
Knighton, Lt. Heywood J. (Student), Orange, Va.
Knizek, Jan O., Cia. Mexicana de Tubos de Albanal, S. A., Ferrocarriles Nacionales 200, Mexico, D. F., Mexico
Knoblaugh, Walter C., 225 E. Market St., Tiffin, Ohio
Knoesel, W. F., Mitchell Clay Mfg. Co., 5627 Manchester Ave., St. Louis 10, Mo.
Knoll, William F., Box 877, New Haven, Conn.
Knowles, Edwin M., China Co. (J. W. Hepplewhite), Newell, W. Va.
*Knowles, W. V., 1150 Sylvania Rd., Cleveland Heights 21, Ohio
Knox Glass Associates, Inc. (R. R. Underwood), Knox, Pa.
Knox Glass Bottle Co. (J. H. Levis), Knox, Pa.
Kocatopcu, Sahap S. (Student), Dept. of Ceramics, Massachusetts Inst. of Tech., Cambridge 39, Mass.
Koch, Frank, National Sales Corp., 31 E. Thirteenth St., Cincinnati 10, Ohio
Koch, William J. (Student), 407 Lincoln Ave., Highland Park, N. J.
Kocher, Daniel W., 6643 S. Harvard Ave., Chicago 21, Ill.
Kochs, Herbert W., 53 W. Jackson Blvd., Room 950, Chicago 4, Ill.
†Koehler, W. A., Mineral Industries Bldg., Morgantown, W. Va.
*†Koenig, Lt. C. J., c/o G. H. Spencer-Strong, 4134 Westview Rd., Baltimore 18, Md.
Koenig, E. W., Erwin, Tenn.
Koenig, F. J. M., 602 W. Main St., Dundee, Ill.
*†Koenig, John H., 1218 N. Troy St., Arlington, Va.
Kohler Co. (Carl J. Kohler), Kohler, Wis.
Kohler, Anthony M., Babcock & Wilcox Co., 85 Liberty St., New York 6, N. Y.
Kohler, Carl J., Kohler Co., Kohler, Wis.
Kohn, George F., Precision Grinding Wheel Co., 8301 Torresdale Ave., Philadelphia, Pa.
Kohn, Joseph, Universal Dental Co., 48th and Brown Sts., Philadelphia, Pa.
Kohne, Frank H., 1700 3rd Ave., New Brighton, Pa.
Kolb, William B., Meadow and Jackson Sts., Philadelphia, Pa.
†Kolstad, John H., 243 Long Acre Rd., Rochester, N. Y.
†Koos, E. K., Sterling China Co., East Liverpool, Ohio
Kopp Glass, Inc. (C. E. Leberknight), Swissvale, Pa.
Koppers Co. (Carl D. Ulmer), Research Dept., 945 Koppers Bldg., Pittsburgh, Pa.
Koupal, Walter G., Pittsburgh Plate Glass Co., Clarksburg, W. Va.
Kraftile Co. (C. W. Kraft), Niles, Calif.
Kraft, C. W., Kraftile Co., Niles, Calif.
Krampf, Francis G., 145 Walnut St., Corning, N. Y.
*†Kraner, Hobart M., Research Dept., Bethlehem Steel Co., Bethlehem, Pa.
Kraus, Charles E., Kraus Research Labs., Sparks, Md.
Krause, George, 2321 N. Maple Ave., Zanesville, Ohio
Kreger, John M., 123 Prospect St., Woodbridge, N. J.
Krehbiel, Frederick H., 88 Lincoln Ave., Pataskala, Ohio
Krehbiel, H. O., Accurate Pyrometric Cone Co., Pataskala, Ohio
Kreidl, Pvt. E. L., Engineer Board Det., Engineer Board, Ft. Belvoir, Va.
Kreidl, Ignaz, 155 Waverly Place, New York 14, N. Y.
Kreidl, Norbert J., 475 Gardham Rd., Rochester, N. Y.
Kreidl, Werner, 155 Waverly Place, New York 14, N. Y.
†Kriegel, Major William W., El Paso, Texas
Krill, Ensign K. E., Naval Air Sta., Norfolk, Va.
Kruesi, Paul J., American Lava Corp., Chattanooga 5, Tenn.
Kruson, Joseph H., Big Savage Refractories Corp., Frostburg, Md.
†Kuechler, Adolph, 27 Banks St., Waltham 54, Mass.
Kumar, Raj, Khemchand Rajkumar, Jullundur City, Punjab, India.
†Kunzman, Edward E., 460 12th St., Niagara Falls, N. Y.
Kurz, Walther, 81 Smith St., Perth Amboy, N. J.
Kutchka, Karl G., 609 Whitney Ave., Wilkinsburg, Pittsburgh 21, Pa.
Kwate, Bernard, 635 Laurel St., Pine Bluff, Ark.
Kyle, H. Clinton, 34 Radium St., Pittsburgh, Pa.

Laclede-Christy Clay Products Co. (W. F. Godejohn), 1711 Ambassador Bldg., St. Louis, Mo.
Lacy, Roy, Pacific Clay Products, Box 145, Sta. A, Los Angeles 31, Calif.
Laird, Clinton N., c/o Mrs. L. A. Klingler, 757 Pierpont St., Rahway, N. J.
Laird, Stanley M., Box 1948, Las Vegas, Nev.
†Lambe, C. M., 1034 Murray Hill Ave., Pittsburgh, Pa.
Lambelet, Clarence A. (Student), Cuba, Mo.
Lambertson, Wingate A., Rich Square, N. C.
Lambie, J. M., Findlay Clay Products Co., Washington, Pa.

†Lampman, Charles M., Jr., Narragansett Ave., R. D. 1, Pittsfield, Mass.
Lancaster Iron Works, Inc. (Frank A. Fix), Lancaster, Pa.
Lancaster Lens Co. (H. G. Crumbaker), 220–226 W. Main St., Lancaster, Ohio
Land, Lt. T. T., Emporia, Va.
Landron, Rafeal, Jr., Box 272, Corning, N. Y.
*Landrum, R. D., Harshaw Chemical Co., 1945 East 97th St., Cleveland 6, Ohio
Lane, George J., 88 Linden Ave., Metuchen, N. J.
†Lane, Richard O., Macklin Co., Jackson, Mich.
Lang, George F., Carr-Lowrey Glass Co., Box 356, Baltimore 3, Md.
Lang, Cpl. Stewart M. (Student), New York, N. Y.
Lange, Louis A., 2603 St. Clair Ave., East Liverpool, Ohio
Langseth, Emma (Student), Box 291, Alfred, N. Y.
Lankford, H. Y., 648 Roosevelt St., Gary, Ind.
Lannes, Eugene M., 243 Rock St., Fostoria, Ohio
Lantz, Donald L., 401 Murray Ave., Fairmont, W. Va.
Lapp Insulator Co., Inc. (K. E. Stettinius), Le Roy, N. Y.
†Lapp, G. W., Lapp Insulator Co., Inc., Le Roy, N. Y.
Larkin, Charles, II, Eden, N. Y.
Larkin, Paul G., Box 371, Campbell, Calif.
Larson, Leonard N. (Student), 800 Archibald, Kansas City, Mo.
Lassman, Benjamin, Hydraulics, Inc., Oliver Bldg., Pittsburgh, Pa.
Laster, Sidney E. (Student), 142 Hamilton St., New Brunswick, N. J.
Latchford-Marble Glass Co. (Baird Marble), Box 4707, Florence Branch, Los Angeles 1, Calif.
†Latimer, Horace L., 1709 Copeman Blvd., Flint, Mich.
Lauck, Donald G., E. J. Lavino and Co., 1819 Oliver Bldg., Pittsburgh 22, Pa.
Laughlin, Homer, China Co. (Joseph Wells), Newell, W. Va.
Laurens Glass Works, Inc. (E. D. Easterby), Laurens, S. C.
Lava Crucible Co. of Pittsburgh (Furman South, Jr.), 627 Wabash Bldg., Pittsburgh, Pa.
Lawrence Clay Co. (H. H. Stephenson), Jackson, Ohio
Lawrence, Frederick B., Box 148, Newell, W. Va.
Lawrence, Ralph V. (Student), R. D. 1, Box 20, Christiansburg, Va.
Lawrence, Willis G., American Brake Shoe Co., Metallurgical Dept., Mahwah, N. J.
Lawton, A. V., Harker Pottery Co., Chester, W. Va.
Lazar, Lt. Paul (Student), Fort Riley, Kans.
Lea, Arthur C., Residence National Smelting Co., Ltd., Avonmouth, Bristol, England
Leavy, John C., 64 Netherwood Ave., Plainfield, N. J.
Leberknight, C. E., Kopp Glass, Inc., Swissvale, Pa.
Lee Clay Products Co. (Martin S. Bowne), Clearfield, Ky.
Lee, Harley C., Basic Magnesium, Inc., Henderson, Nev.
†Lee, P. William, 205 Elmwood Blvd., York, Pa.
Lee, Virgil J., 638 Arkansas St., Lawrence, Kans.
Leech, John L., Findlay Clay Products Co., Washington, Pa.
Lees, Arch A., 411 Avon Dr., Pittsburgh 16, Pa.
†Leibson, J. S., Porcelain Dept., General Electric Co., Schenectady, N. Y.
Leighton, M. M., 100 Natural Resources Bldg., State Geological Survey, Urbana, Ill.
Leitten, Carl F., 50 Hawkins Ave., Hamburg, N. Y.
Lemmerman, Paul C., E. I. du Pont de Nemours & Co., Inc., Grasselli Chemicals Dept., 3092 Broadway, Cleveland 15, Ohio
LeMunyon, James S., 250 Wayne St., Mansfield, Ohio
*Lenchner, Theodore, 5720 Munhall Rd., Pittsburgh 17, Pa.
Lennon, John W., 303 Highfield Lane, Nutley 10, N. J.
Lenz, Vernon W., Owens-Corning Fiberglas Corp., Newark, Ohio
Lesar, Albert R., 408 Yale St., Mexico, Mo.
Lester, Frank P., 953 Goss Rd., Cincinnati 29, Ohio
*Lester, W. Ronald, 4112 Ethland Ave., Baltimore 7, Md.
Levi, Ormonde S., Save Electric Corp., 615 Front St., Toledo 5, Ohio
Levis, J. H., Knox Glass Bottle Co., Knox, Pa.
Lewis, Evan J., 218 Watauga Ave., Corning, N. Y.
†Lewis, Gordon E., 156 Tulpehocken Ave., West Reading, Pa.
Lewis, J. H., Blue Ridge Glass Corp., Kingsport, Tenn.
Libbey Glass, Div. of Owens-Illinois Glass Co. (H. R. Black), Toledo 1, Ohio
Libbey-Owens-Ford Glass Co. (George B. Watkins), 1701 E. Broadway, Toledo, Ohio
Liberty Glass Co. (George F. Collins, Jr.), 317 E. Lee, Sapulpa, Okla.
*Lillie, Howard R., 191 Delevan Ave., Corning, N. Y.
Lilly, Adam, 8010 Hohman Ave., Munster, Ind.
†Limes, Capt. Robert W., 1901 Aberdeen Ave., Columbus 3, Ohio
Lin, Cho-Yuan, Ferro Enamel Corp., 4150 East 56th St., Cleveland 5, Ohio
Lindquist, Claude A., Jr., 8 Gwendolyn Ave., Jamestown, N. Y.
Lindsay, George W., 2301 Blake St., Box 5510, Terminal Sta., Denver 17, Colo.
Linkhorn, William H. (Student), 171 Chittenden Ave., Columbus, Ohio
*†Lintz, E. H., 617 North 7th St., Cambridge, Ohio
Linz, Arthur, Climax Molybdenum Co., 500 Fifth Ave., New York 18, N. Y.
Little, H. B., Baltimore Enamel & Novelty Co., Box 928, Baltimore, Md.
*Littleton, J. T., Corning Glass Works, Corning, N. Y.
Littrell, Lawrence W., Dominion Minerals, Inc., Piney River, Va.
Liu, Konleon, 21 Harrison Ave., Boston, Mass.
†Lobaugh, Frank E., 1111 E. Front St., Plainfield, N. J.
Locke Insulator Corp. (J. M. Gilfillan), Box A, Baltimore, Md.
Long, George R., Frigidaire Div., General Motors Corp., Dayton, Ohio
Long, Luther L., Owens-Corning Fiberglas Corp., Newark, Ohio
Long, Robert, American Porcelain Enamel Co., 1205 Keating Ave., Muskegon 36, Mich.
Long, Robert R., 130 W. Culbertson St., Fostoria, Ohio
Long, Russell E., 232 N. Market St., Ligonier, Pa.
*†Loomis, George A., Engr. Expt. Sta., Ohio State Univ., Columbus 10, Ohio
Loring, Albert D., 1278 Michigan Ave., Cincinnati, Ohio
†Louden, R. H., McGean Chemical Co., 1106 Republic Bldg., Cleveland 15, Ohio
Loughridge, Frederick A. (Student), 183 West 6th St., Corning, N. Y.
Louisville Fire Brick Works (Louis Ernst), 4554 Louisville Ave., Louisville 9, Ky.
Louthan Mfg. Co. (William B. Louthan), East Liverpool, Ohio
Louthan, William B., Louthan Mfg. Co., East Liverpool, Ohio
Love, L. G., National Lime and Stone Co., First National Bldg., Findlay, Ohio
*Lovejoy, Ellis (Charter Life), 480 West 6th Ave., Columbus, Ohio
Lowe, George K., 1711 Compton Rd., Cleveland Heights, Ohio
Loy, John G., Porcelain Products, Inc., Box 300, Findlay, Ohio
Lucas, Joseph M., 1758 10th St., Cuyahoga Falls, Ohio
Lucke, Charles E., Columbia Univ., Pupin Bldg., New York 27, N. Y.
Lueders, Roland, 3241 Bradford Rd., Cleveland Heights 18, Ohio
Lukas, J. C., Ransome Machinery Co., Dunellen, N. J.
Lukens, Alan R. (Student), 11 Windsor St., Cambridge, Mass.
†Luks, Daniel W., Barbertown Rd., Frenchtown, N. J.
Lull, Stanley E., Sylvania Electric Products, Inc., 126 Washington St., Salem, Mass.
Lund, Evelyn C., 1006 Pasadena Dr., Fort Wayne 6, Ind.
Lund, Melvin S., 2363 S. Freedom Ave., Alliance, Ohio
Lund, Richard J., 70 Mason Dr., Manhasset, N. Y.

*Lundell, Gustav E. F., National Bureau of Standards, Washington 25, D. C.
Lunn, C. A., Consolidated Edison Co. of New York, Inc., 4 Irving Place, New York 3, N. Y.
Luster, Vaylord R., 490 Canton, Detroit 7, Mich.
Luther, Harry E., Concord, Calif.
Lutton, X. W., 347 Haddon Ave., Collingswood, N. J.
*Lyle, Aaron K., 21 Cumberland Rd., West Hartford 7, Conn.
Lynch, A. J., & Co. (W. W. Cadwallader), 2424 Enterprise St., Los Angeles 21, Calif.
Lynch, Eugene D., 204 Ceramics Bldg., Univ. of Illinois, Urbana, Ill.
†Lynn, Bert M., c/o Mr. A. Lynn, 19 Willard Ave., Mt. Vernon, N. Y.
Lynn, H. K., Summitville Face Brick Co., Summitville, Ohio
Lyon, Kenneth C., Armstrong Cork Co., Millville, N. J.
Lyon, Louis, Jr., National Refractories Co., Inc., Oliver Bldg., Pittsburgh, Pa.
Lyons, Robert L., Waltham Grinding Wheel Co., Waltham, Mass.
Lyons, S. C., 133 Lowell St., Arlington Heights 74, Mass.
Lytle, W. O., Pittsburgh Plate Glass Co., Research Lab., Creighton, Pa.

MacAlpine, William M., 357 E. Main St., Somerville, N. J.
MacDonald, James E., 713 Highland Ave., Latrobe, Pa.
MacDonald, Ronald, Primrose Brick Works, Nigel, Transvaal, South Africa
†MacDonald, R. W., 22 Holly Rd., Oakmont, Wheeling, W. Va.
Mack, Edward, Jr., 309 Walhalla Dr., Columbus, Ohio
Mackasek, Edward, 1010 Vermont Ave., N. W., Washington 5, D. C.
MacKenzie, James T., 4300 Glenwood Ave., Birmingham 5, Ala.
Maddock, A. M., Titusville, N. J.
†Maddock, J. B., Paper Makers Importing Co., Inc., Easton, Pa.
Magnuson, J. W., 345 S. Race St., Denver, Colo.
Mahaffy, Wendel A., Owens-Illinois Glass Co., 601 36th Ave., Oakland 1, Calif.
Majeske, Joseph, T. C. Wheaton Co., Millville, N. J.
Malkin, W. R., B. F. Drakenfeld & Co., Inc., East Liverpool, Ohio
Mallinger, Benjamin, Samuel Mallinger Co., 1855 Forbes St., Pittsburgh 19, Pa.
Mallinger, Samuel Co. (Benjamin Mallinger), 1855 Forbes St., Pittsburgh 19, Pa.
†Malm, Arthur T., 233 Beverly Rd., Worcester, Mass.
Malsch, Werner, 402 6th Ave., Belmar, N. J.
Mansfield Sanitary Pottery, Inc. (H. A. Hoare), Perrysville, Ohio
*Manson, M. E., 5633 Arch Crest Dr., Los Angeles 43, Calif.
Mansur, Howard, 151 S. Washington St., Spokane 8, Wash.
Marbaker, Edward E., Mellon Inst., Oakland Sta., Pittsburgh 13, Pa.
Marble, Baird, Latchford-Marble Glass Co., Box 4707, Florence Branch, Los Angeles 1, Calif.
Marienville Glass Co. (Clarence R. Deible), Marienville, Pa.
†Marley, Henry E., 501 Loveman Ave., Colonial Hills, Worthington, Ohio
Marlow, James A. (Student), c/o Mrs. J. F. Marlow, 119 33rd St., W., Saskatoon, Saskatchewan, Canada
Marquis, John E., Engr. Expt. Sta., Ohio State Univ., Columbus 10, Ohio
Marsh, Frank L., National Gypsum Co., Clarence Center, N. Y.
Marshall-Eclipse Div. of Bendix Aviation Corp. (F. Weyburne), Box 538, Troy, N. Y.
Marshall, Paul A., 1201 Cherry St., Brockway, Pa.
Martin, Frank B., R. D., Sunset Blvd., Cape May, N. J.
Martin, John E., 2410 West 18th St., Chicago, Ill.
Martin, John R., 1125 W. Mistletoe Ave., San Antonio 1, Texas
Martin, Ralph H., 2300 East 52nd St., Los Angeles 11, Calif.
Martin, Randolph M., Box 951, Nacogdoches, Texas
Martin, Richard H., 51 Nelson Place, Worcester 5, Mass.
Martin, Robert F., 4125 Garrison St., N. W., Washington 16, D. C.
Martin, Wesley G., 6054 N. Kent Ave., Milwaukee 11, Wis.
Martz, Joseph A., 535 Riverside Ave., Wellsville, Ohio
Marx, Leroy, Denver Terra Cotta Co., W. First Ave. and Umatilla St., Denver, Colo.
Maryland Glass Corp. (L. C. Roche), 2143 Wicomico St., Baltimore 30, Md.
Mason, A. G., R. Thomas & Sons Co., Lisbon, Ohio
Mason, Lloyd W., Camp Campbell, Ky.
Massengale, Gordon B., 2740 Porter St., N. W., Apt. 1, Washington 8, D. C.
Mathews, William J., Brockway Glass Co., Inc., Brockway, Pa.
Mathiasen, O. E., Federal Seaboard Terra Cotta Corp., Perth Amboy, N. J.
Mathieson Alkali Works, Inc. (G. P. Vincent), 60 East 42nd St., New York 17, N. Y.
Matiste, Henry J., 2404 Highland Ave., New Castle, Pa.
Matson, Frederick R., Central Testing Labs., Armstrong Cork Co., Lancaster, Pa.
Matteson, Gilbert D., 14 Belleview Place, New Rochelle, N. Y.
Matthews, Leslie G., 120 Broadway, New York 5, N. Y.
Maurer, James A., 5519 N. Lake Dr., Milwaukee 11, Wis.
Mavor, Wilfrid, Ferro Enamels (Canada), Ltd., 629 Wellington St., Ottawa, Ontario, Canada.
Maxson, Elwyn L., 1526 Canada Blvd., Glendale, Calif.
Maxson, Elwyn L., 1526 Canada Blvd., Glendale, Calif.
Maybaum, Paul S., Jr. (Student), 124 Midland Blvd., Maplewood, N. J.
Mayer, Walter S., Mayer China Co., Beaver Falls, Pa.
Mays, George A., Niles, Calif.
*†McAfee, W. Keith, 235 Hazelcroft Ave., New Castle, Pa.
McAlpine, Kenneth B., 1201 Union Ave., Brackenridge, Pa.
McBride, P. B., Porcelain Metals Corp. of Louisville, 1400 South 13th St., Louisville 10, Ky.
*McBurney, John W., National Bureau of Standards, Washington 25, D. C.
†McCann, D. M., Akron Porcelain Co., Akron 14, Ohio
McCann, F. A., R. D. 3, Box 907, Stockton, Calif.
McCann, Robert J., 2401 State St., Granite City, Ill.
†McCann, Sidney W., Pfaudler Co., Rochester 4, N. Y.
McCartt, Kenneth C., 327 Crescent Ave., New Castle, Pa.
McCarty, J. E. D., Simmonds Aerocessories, Inc., 37–28 30th St., Long Island City 1, N. Y.
*McCauley, George V., Corning Glass Works, Corning, N. Y.
McClure, Howard C., 1808 Hutchins St., Portsmouth, Ohio
McCollom, Perry C., New Castle Refractories Co., Box 230, New Castle, Pa.
McComas, Clarence B., T. C. Wheaton Co., Millville, N. J.
McCormick, Major John M., San Francisco, Calif.
McCoy, Nelson, Roseville, Ohio
McCoy, William, 634 Adair Ave., Zanesville, Ohio
McCreery, George L., 393 Highland Ave., Wadsworth, Ohio
McCreight, D. O., 819 S. Braddock Ave., Pittsburgh 21, Pa.
McCreight, Louis R. (Student), Ceramic Lab., Massachusetts Inst. of Tech., Cambridge, Mass.
McCrone, Elizabeth B. (Student), 185 Edgewood Ave., San Francisco, Calif.
McCutchen, Earl S., Engr. Expt. Sta., Ohio State Univ., Columbus 10, Ohio
McDanel, Walter W., 1471 Fourth St., New Brighton, Pa.

McDevit, William F. (Student), 185 Forest Ave., Tompkinsville, Staten Island, N. Y.
McDonald, E. F., Ingram-Richardson Mfg. Co., Beaver Falls, Pa.
*McDougal, Taine G., A C Spark Plug Co., Flint 2, Mich.
*McDowell, J. S., 4716 Bayard St., Pittsburgh, Pa.
*†McDowell, Samuel J., American Lava Corp., Chattanooga 5, Tenn.
†McElroy, R. H., International Clay Machinery Co., Dayton, Ohio
McFeely Brick Co. (R. R. Hendren), 816 Ligonier St., Latrobe, Pa.
McGean, Ralph L., 1106 Republic Bldg., Cleveland 15, Ohio
McGohan, G. William, American Rolling Mill Co., Middletown, Ohio
McGolpin, William C., Rm. 416, 57 Bloor St., W., Toronto 5, Ontario, Canada
McGrue, William M., 10231 Prospect Ave., Chicago 43, Ill.
McHose, L. H., Inc. (M. M. McHose), Box 345, Perth Amboy, N. J.
McHose, M. M., L. H. McHose, Inc., Box 345, Perth Amboy, N. J.
McHugh, M. J., Jr., Consolidated Feldspar Corp., 1403 Trenton Trust Bldg., Trenton 8, N. J.
McIntosh, Harold W., Hartford-Empire Co., Hartford, Conn.
*†McIntyre, G. H., Ferro Enamel Corp., 4150 East 56th St., Cleveland 5, Ohio
McKaig, W. Wallace, Cumberland Steel Co., Cumberland, Md.
McKee Glass Co. (Gerald Terrill), Jeannette, Pa.
McKee, Arthur G., & Co. (J. P. Irwin), 2300 Chester Ave., Cleveland 1, Ohio
McKee, Carolyn, R. D. 7, Mahoningtown, Pa.
McKee, F. W., Salem China Co., Salem, Ohio
McKendrick, Alexander, Glenboig Union Fireclay Co., Ltd., Star Works Lab., Glenboig, Lanarkshire, Scotland
McKeown, Thomas H., Box 31, Metuchen, N. J.
McKinnell, Mrs. Eloise M. (Student), 6219 12th Ave., N. E., Seattle, Wash.
McKinnell, Lt. James F., Jr. (Student), San Francisco, Calif.
McKinnie, James R., 804 San Ysidro, Upland, Calif.
McLain Fire Brick Co. (W. A. Turner), 1239 Gulf Bldg., Pittsburgh 19, Pa.
McLaren, Henry D., 375 Daly Ave., Ottawa, Ontario, Canada
McLaughlin, N. H., Alsey Brick & Tile Co., Alsey, Ill.
McLeod & Henry Co., Inc. (George A. Soper, Jr.), 357 First St., Troy, N. Y.
*†McMahon, John F., Alfred, N. Y.
McMaster, Harold A., 619 Toronto St., Toledo 9, Ohio
†McNamara, Edward P., Dept. of Ceramics, Rutgers Univ., New Brunswick, N. J.
McNaughton, Ronald R., Central Tech. Library, Consolidated Mining & Smelting Co. of Canada, Ltd., Trail, British Columbia, Canada
McNutt, Harold M., 724 N. Victory Blvd., Burbank, Calif.
*†McVay, T. N., School of Chemistry, Metallurgy, and Ceramics, Univ. of Alabama, University, Ala.
Meacham, Floran L., 1009 Bonnie Brae, River Forest, Ill.
Meacham, Frank, Chattanooga Glass Co., Chattanooga 10, Tenn.
Medert, Warren C., 797 Deshler Ave., Columbus 6, Ohio
Meeker, R. C., Kentucky-Tennessee Clay Co., 807 City Savings Bldg., Alliance, Ohio
Meharg, Laurence, Hazel-Atlas Glass Co., 15th and Jacob Sts., Wheeling, W. Va.
Meloy, Charles L., 55 Elm St., Apt. 1, Westfield, N. J.
Mercer, L. D., Republic Steel Corp., Republic Bldg., Cleveland 1, Ohio
Merck, Walter J., 20 Lowell Rd., Port Washington, Long Island, N. Y.
Merriam, Jack G., 20 Kline Rd., R. D. 1, Lewiston, N. Y.
†Merritt, Clarence W., Box 464, Alfred, N. Y.
†Merritt, Lester M., 654 Wilson Ave., Columbus 5, Ohio
†Merry, E. B., Jr., Merry Brothers Brick & Tile Co., 415 Masonic Bldg., Augusta, Ga.
Merry, W. H., National Sanitary Co., Salem, Ohio
Merwin, Byron W., 2505 B, St. Clair Ave., East Liverpool, Ohio
Merz, George, Magnesita, S. A., Caixa Postal 208, Belo-Horizonte, Brazil
Messimer, Laverne A., 6007 Welborn Dr., Washington 16, D. C.
Metal & Thermit Corp., 120 Broadway, New York 5, N. Y.
Metalloy Corp. (Walter M. Fenton), 1320 Rand Tower, Minneapolis, Minn.
Metsch, C. G., Highland Colony, East Liverpool, Ohio
Metz, G. F., Farquhar Estates, R. D. 6, York, Pa.
Metzger, A. J., Louisville Fire Brick Works, Inc., Louisville 9, Ky.
Mexicana de Tubos de Albanal, S. A. (Jan O. Knizek), Ferrocarriles Nacionales 200, Mexico, D. F., Mexico
Mexico Refractories Co. (C. A. Smith), Mexico, Mo.
Meyer, George W., Glenshaw Glass Co., Inc., Glenshaw, Pa.
Meyer, H. C., Foote Mineral Co., 1609 Summer St., Philadelphia, Pa.
Meyer, Henry E., 839 Reilly Rd., Wyoming, Ohio
Meyer, Herbert T., c/o L. J. Meyer, 247 N. Indiana Ave., Kankakee, Ill.
Meyer, Miss Ursula, 260 Riverside Dr., New York, N. Y.
Meyer, William W., U. S. Tariff Commission, Washington, D. C.
Michael, Frank L., 88 North St., Dalton, Mass.
Middleswarth, Earl T., Walnut St., Reedsville, Pa.
Middleton, George J., Gladding, McBean & Co., Lincoln, Placer County, Calif.
Millen, Charles T. (Student), 553 Sherbourne St., Toronto, Ontario, Canada
Miller, Esther, State Dept. of Geology & Mineral Industries, 702 Woodlark Bldg., Portland 5, Oregon
Miller, Frank K., 92 E. First St., Corning, N. Y.
Miller, Fred W., 13 Rynda Rd., Maplewood, N. J.
Miller, Grant E. (Student), 407 E. Erie St., Painesville, Ohio
†Miller, James L., Johns-Manville Products Corp., Zelienople, Pa.
Miller, John W., New Castle Refractories Co., New Castle, Pa.
Miller, O. E., Pyro Clay Products Co., Oak Hill, Ohio
*Miller, Robert A., Pittsburgh Plate Glass Co., 2000 Grant Bldg., Pittsburgh 19, Pa.
Miller, R. W., Pittsburgh Plate Glass Co., Columbia Chemical Div., Barberton, Ohio
Miller, William A. (Student), 125 Halstead Rd., Elizabeth, N. J.
Miller, William J., 7702 Edgewood Ave., Swissvale, Pa.
Milligan, Chester E., 4814 Loma Vista Ave., Los Angeles, Calif.
Milligan, Lowell H., Norton Co., Research Lab., New Bond St., Worcester 6, Mass.
Milliken, Edward C., 444 W. North Ave., East Palestine, Ohio
†Milliken, G. Edward, Van Ormer Brick Co., Pitcairn, Pa.
Millman, Nathan, Huber Co., Inc., Huber, Ga.
Millsom, Walter C., W. S. Dickey Clay Mfg. Co., 607 Commerce Trust Bldg., Kansas City, Mo.
Millspaugh, Raymond E., 23 E. First St., Corning, N. Y.
Mink, John D., 455 N. Main St., Dunkirk, Ind.
Minnick, L. John, 306 Boyer Rd., Cheltenham, Pa.
Minnium, Byron B., Erie Resistor Corp., 644 West 12th St., Erie, Pa.
†Minton, G. Z., Pittsburgh Plate Glass Co., Research Lab., Creighton, Pa.
Mississippi Glass Co. (R. D. Humphreys), 200 Fifth Ave., New York 10, N. Y.
Mitchell Clay Mfg. Co. (W. F. Knoesel), 5627 Manchester Ave., St. Louis 10, Mo.
Mitchell, Lt. E. T. (Student), 224 Greenwood Circle, Decatur, Ga.
†Mitchell, Lt. (jg) Lane, 525 Commander Hotel, Cambridge 38, Mass.
Mitchell, M. P., Fairfacts Co., Inc., Box 374, Trenton 3, N. J.

†Mitra, H. K., 12 A Rd., East, Jamshedpur, B. N. R., India
Mochel, John M., 209 E. First St., Corning, N. Y.
Mockrin, Isadore, 1544 E. Broad St., Apt. 102, Columbus 3, Ohio
Modigliani, Piero, Modigliani Glass Fibers, Inc., 542 West 27th St., New York 1, N. Y.
Moffat, John, Jr., 7126 Middleton St., Apt. 26, Huntington Park, Calif.
Moffett, Mrs. Bernice P., Carr-Lowrey Glass Co., Box 356, Baltimore 3, Md.
Moffett, Capt. Robert A., Camp Davis, N. C.
Mohl, Helmuth, Fabrica de Loza "El Anfora," S. A., Apartado 508, Mexico, D. F., Mexico
Mohr, John G., Corning Glass Works, Corning, N. Y.
Mohr, William C., 1178 South Ave., Wilkinsburg 21, Pa.
Moler, Messrs., Products, Ltd., Hythe Works, Colchester, Essex, England
Monack, A. J., 155 Union Ave., Rutherford, N. J.
Mong, Lewis E., 8506 Loughborough Place, Chevy Chase, Md.
*†Montgomery, E. T., Engr. Expt., Sta., Ohio State Univ., Columbus 10, Ohio
*Montgomery, Robert J., Mining Bldg., Univ. of Toronto, Toronto, Ontario, Canada
Moody, H. Leslie, Rookwood Pottery, Mount Adams, Cincinnati 2, Ohio
Mooney, Edward L., 103 Pleasant St., Norwich, N. Y.
Mooney, Kurt M., 32 Arcadia Place, Vineland, N. J.
†Mooney, William F., 1267 Glenneyre St., Laguna Beach, Calif.
Moore Enameling & Mfg. Co. (Walter B. Moore), West Lafayette, Ohio
Moore & Munger (Murray Rushmore), 33 Rector St., New York 6, N. Y.
Moore, Carl E., John Douglas Co., 71st Street and B.&O. R.R., Cincinnati 16, Ohio
Moore, Dwight G., Ceramic Div., National Bureau of Standards, Washington 25, D. C.
†Moore, Richard S., Harbison-Walker Refractories Co., Farmers Bank Bldg., Pittsburgh 22, Pa.
Moore, Walter B., Moore Enameling & Mfg. Co., West Lafayette, Ohio
Moorshead, T. C., United Glass Bottle Mfgrs., Ltd., 8, Leicester St., London, W. C. 2, England
Moran, J. J., Landis Ave. and Spring Rd., Vineland, N. J.
Moranty, Adam F., 1800 Keith Bldg., Cleveland 15, Ohio
*Morey, G. W., Geophysical Lab., 2801 Upton St., Washington 8, D. C.
Morgan, Jack E. (Student), Phi Gamma Delta, State College, Pa.
Morgan, Stuart F., 18 Cooke St., Fairhaven, Mass.
Morgan, Willard L., 1603 Guilford Rd., Columbus 8, Ohio
*†Morgan, William R., 6 High St., Westboro, Mass.
Morris, Frank, 236 Greenpoint Ave., Brooklyn 22, N. Y.
*†Morris, George D., 229 Fairfield Ave., New Castle, Pa.
Morris, George J., Box 1, Sykesville, Pa.
Morris, John L., New York, N. Y.
†Morrison, Neil T., 217 Greylock Parkway, Belleville 9, N. J.
Morrison, W. S., Illinois Water Treatment Co., Rockford, Ill.
Morrow, C. T., Northwest Magnesite Co., Cape May, N. J.
Morton Pottery Co. (William Rapp), Morton, Ill.
Morton, William A., 1317 Fulton Bldg., Pittsburgh, Pa.
Mosaic Tile Co., Zanesville, Ohio
†Moser, John L., 53 Rockhill Ave., Dayton 9, Ohio
Moser, Leo, 200 Riverside Dr., New York 25, N. Y.
Moses, Sidney A., 2250 Cathedral Ave., N. W., Washington 8, D. C.
Mosley, Norman B., 85 E. 18th Ave., Columbus 1, Ohio
Moss, Vernon W., Box 223, Lompoc, Calif.
Motsch, Fred R., Foster-Forbes Glass Co., Marion, Ind.
Mott, B. H., Mott Core Drilling Co., Huntington, W. Va.
Mount Clemens Pottery Co. (C. E. Doll), Mount Clemens, Mich.
Mouraud, Paul H., National Tile Co., Anderson, Ind.
Mowrey, Fred W., 405 Jones St., Belle Vernon, Pa.
Moyer, Robert E., 234 Mulberry St., Coshocton, Ohio
†Mueller, Capt. James I., Camp Edwards, Mass.
Mueller, R. M., Ferro Enamels (Australia) Pty., Ltd., Bourke Rd., Alexandria, N. S. W., Australia
Mullady, Russell E., 1006 College Ave., Niagara Falls, N. Y.
Muller, Frederick W., 452 N. George St., Millersville, Pa.
†Muller, Max M., 623 Ave. G, Boulder City, Nev.
Mullite Refractories Co. (Charles W. Fyfe), Shelton, Conn.
†Mulroy, James P., 965 Lafayette Ave., Buffalo 9, N. Y.
Mulryan, Henry, 417 S. Hill St., Rm. 926, Los Angeles 13, Calif.
Mulvane, O. E., Box 117, West Lafayette, Ohio
†Mundy, O. S., 426 Park Ave., Wheaton, Ill.
Munroe, George C. (Student), 28 Boulevard, Glen Rock, N. J.
Murchison, D. C., 230 Park Ave., New York 17, N. Y.
Murgatroyd, John B., Rockware Glass Syndicate, Ltd., 142/3, Audrey House, Ely Place, London, E. C. 1, England
Murphy, Edward P., Jr. (Student), 404 S. Mathews, Urbana, Ill.
Murphy, Remington M., 705 Avery Ave., Syracuse 4, N. Y.
Murray, Gerard A., R. D. 6, Box 512, Bessemer, Ala.
Murray, James A., Warner Co., Devault, Pa.
†Murray, Maurice A., 1505 Troupe St., Augusta, Ga.
Musselman, H. G., 2301 Tacoma St., Baltimore 30, Md.
Myers, C. H., Box 127, Salt Lake City, Utah
†Myers, Charles V., 516 N. Jefferson St., Kittanning, Pa.
Myers, E. F., Ironton Fire Brick Co., 707 Carolina Life Bldg., Box 1324, Columbia, S. C.
Myerson, Martin, Ideal Tooth, Inc., Cambridge 39, Mass.

Nadler, A/C Marion R. (Student), Grand Rapids, Mich.
Nagel, Eric W., 5661 Natural Bridge Ave., St. Louis, Mo.
Nakamura, H. Henry (Student), Box 951, Alfred, N. Y.
*Nash, Harold S., Ceramics Dept., Univ. of Cincinnati, Cincinnati, Ohio
Nash, Simeon, Jr., 156 South 17th St., Columbus 5, Ohio
National Ceramic Co. (Nicholas H. Snyder), 400 Southard St., Trenton 2, N. J.
National Engineering Co. (F. W. Fuller), 549 W. Washington Blvd., Chicago 6, Ill.
National Fireproofing Corp. (R. A. Shipley), 202 E. Ohio St., N. S., Pittsburgh, Pa.
National Gypsum Co. (J. Fred Chambers), Luckey, Ohio
National Industrial Sand Assn. (V. P. Ahearn), 951 Munsey Bldg., Washington, D. C.
National Lead Co. (Alexander Stewart), 105 York St., Brooklyn, N. Y.
National Lime and Stone Co. (L. G. Love), First National Bldg., Findlay, Ohio
National Refractories Co., Inc. (R. A. Hitchins), 1520 Locust St., Philadelphia 2, Pa.
National Sales Corp. (Frank Koch), 31 E. Thirteenth St., Cincinnati 10, Ohio
*Navias, Louis, General Electric Co., Research Lab., Bldg. 37, 6th Fl., Schenectady, N. Y.
Nederlandsche Vereeniging van Aardewerkfabrikanten, W. P. M. van der Loo, Parkstraat 37a, The Hague, Holland
Neel, Byrd M., Bradford Woods, Pa.
Neiman, Robert, Whip-Mix Corp., Inc., 411 W. Avery Ave., Louisville 8, Ky.
Nelson, Lewis W., 923 Hazel St., New Castle, Pa.
Nelson, Quentin E. (Student), c/o Mrs. T. E. Livingston, 522 S. E. Main St., Portales, New Mexico
Netter, William S., 808 Adee Ave., Bronx, N. Y.
New, Ryland H., National Sewer Pipe Co., Ltd., Swansea, Ontario, Canada
Newark, F. F. (Student), 303 Welch, Ames, Iowa
Newbold General Refractories, Ltd., Box 3407 R, Sydney, N. S. W., Australia
Newbrander, Stanley M., Weirton Steel Co., Weirton, W. Va.

New Castle Refractories Co. (R. W. Rowland), New Castle, Pa.
Newcomb, Rexford, Jr., Conservation Div., War Production Board, Washington, D. C.
Newhouse, Henry, 4103 Third Rd., N., Apt. 1, Buckingham Community, Arlington, Va.
New Jersey Porcelain Co. (Stephen Wenczel), Box 908, Trenton 5, N. J.
Newman, Robert W., Buffalo Tube Works, General Electric Co., 1495 Filmore Ave., Buffalo 11, N. Y.
New Martinsville Glass Co. (Max G. Biberthaler), New Martinsville, W. Va.
Newsom, A. S., Pountney & Co., Ltd., Bristol Pottery, Fishponds, Bristol, England
Newton, R. L., Owens-Illinois Glass Co., Bridgeton, N. J.
Nichols, A. S., 608 S. Dearborn St., Chicago 5, Ill.
Nichols, Ernest H., Funkhouser Co., Hagerstown, Md.
Nicholson, Clifford M., Ancor Corp., Box 565, St. George, S. C.
Nicks, John F., 16 S. F. T. S., Hazersville, Ontario, Canada
Nieman, A. H., Ohio Hydrate & Supply Co., Woodville, Ohio
Niklewski, Bronislaw, Jr., Mazowiecka 45, Poznan, Poland
Nile, Hugh, Industrial Filter Sack Co., Wellsville, Ohio
Nobes, Frederick L., Carborundum Co., Ltd., Manchester, England
Noble, O. C., Tygart Valley Glass Co., Washington, Pa.
Nobles, Melvin A. (Student), 608 Parks Place, Austin 22, Texas
Nodurft, Edgar G. (Student), Strawberry Point, Iowa
Nordberg, Martin E., 244 Chenning St., Corning, N. Y.
Nordmeyer, Rudy L., Mission, Texas
Nordquist, David F., 9 Hockeborn Ave., Auburn, N. Y.
Nordyke, John S., 434 Olympia Rd., Chatham Village, Pittsburgh, Pa.
North American Refractories Co. (E. M. Weinfurtner), National City Bank Bldg., Cleveland, Ohio
North Carolina Feldspar Corp. (W. F. Deneen), Erwin, Tenn.
North State Pyrophyllite Co., Inc. (E. M. Harvey), Pomona, N. C.
Northwestern Glass Co. (Edward S. Campbell), 5801 E. Marginal Way, Seattle 4, Wash.
Norton Co. (Arthur T. Malm), Worcester 6, Mass.
*Norton, Charles L., Jr., Babcock & Wilcox Co., 85 Liberty St., New York 6, N. Y.
*†Norton, Frederick H., Dept. of Metallurgy, Div. of Ceramics, Massachusetts Inst. of Tech., Cambridge 39, Mass.
Norwood, George M., Box 275, Lillington, N. C.
Norwood, John N., Alfred Univ., Alfred, N. Y.
Novinski, Frank S., 1161 Sheridan St., Camden, N. J.
Novy, Anton R., 5204 West 23rd Place, Cicero, Ill.
Nowell, Dorroh L., Jr., 522 Greene St., Augusta, Ga.
Noyes, Bradford, P. R. Mallory & Co., Indianapolis, Ind.
Nunes, J. L., 359 6th St., N. E., Atlanta, Ga.
Nyman, P. V., Ball Brothers Co., Muncie, Ind.

*Oakley, W. W., 31 East 4th St., Corning, N. Y.
O'Bannon, Loran S., 1215 Parksway, N., Columbus 8, Ohio
Oberst, Clair R., Industrial Ceramic Products, Inc., 965 W. Fifth Ave., Columbus 8, Ohio
Odelberg, A. S. W. (Honorary), Allen 18, Djursholm, Sweden
Oesterle, Robert A., 2427 W. Main, Belleville, Ill.
Offill, P. M., Amsler-Morton Co., Inc., Fulton Bldg., Pittsburgh 22, Pa.
Offutt, J. S., United States Gypsum Co., 300 W. Adams St., Chicago 6, Ill.
Ogden, D. P., Ogden Engr. Co., Ottawa, Ill.
*Ogden, Ellsworth P., Harrop Ceramic Service, 35 E. Gay St., Columbus, Ohio
*Ogden, John T., *The Glass Industry*, 55 West 42nd St., New York 18, N. Y.
Ohio Brass Co., Barberton, Ohio
Ohio Clay Co. (George W. Denison), Box 1776, Cleveland, Ohio
Ohio Hydrate & Supply Co. (A. H. Nieman), Woodville, Ohio
Old Hickory Clay Co. (L. F. Powell), Box 271, Paducah, Ky.
Olive, Frank C., 515 Chamber of Commerce Bldg., Indianapolis 4, Ind.
Oliver, W. V., French Saxon China Co., Sebring, Ohio
Olney, Wilson, Rm. 809A, 89 Broad St., Boston, Mass.
Olpin, Albert R., 2045 Wickford Rd., Columbus 8, Ohio
Olsen, Rangwald S., 1938 Estes Ave., Chicago 26, Ill.
Olson, E. E., A. H. Heisey & Co., Newark, Ohio
Olson, Hjalmar, A. B. Gustavsbergs Fabriks, Intressenter, Gustavsberg, Stockholm, Sweden
O'Meara, Robert G., 1400 Elm St., Rolla, Mo.
Onondaga Pottery Co. (B. E. Salisbury), 1856–58 W. Fayette St., Syracuse 4, N. Y.
Opper, F. H., Savannah Kaolin Co., 314 American Bldg., Box 184, Savannah, Ga.
Orefraction, Inc. (Norbert F. Stanny), 7505 Meade St., Pittsburgh 8, Pa.
Orlando, Antonio, Ferrosmalt, S. A., Avenida 18, Julio 1202, Montevideo, Uruguay
†Orlowski, Howard J. (Student), New Haven, Conn.
Orr, Stanley C., Pfaudler Co., Elyria, Ohio
Orth, Howard S., 965 West 5th Ave., Columbus 8, Ohio
Orth, William H., Cambridge Tile & Mfg Co., Cincinnati, Ohio
*†Ortman, Fred B., Gladding, McBean & Co., 2901 Los Feliz Blvd., Los Angeles 26, Calif.
Orton, Edward, Jr., Ceramic Foundation, 1445 Summit St., Columbus 1, Ohio
Ostrander, Eugene C., Kopp Glass, Inc., Swissvale, Pittsburgh 18, Pa.
Ostrander, Van R., 10 Judson Ave., Ardsley, N. Y.
Ott, Lawrence H., Rheem Mfg. Co., Research Div., 1209 East 25th St., Baltimore 18, Md.
Ottoson, Axel C., 4163 Trumbull St., Bellaire, Ohio
Outcault, Harry E., St. Joseph Lead Co., 250 Park Ave., New York 17, N. Y.
Overbeck, Mary F., Cambridge City, Ind.
Owen, F. E., Porcelain Products, Inc., Parkersburg, W. Va.
Owen, Frederick E., Electrical Refractories Co., East Palestine, Ohio
Owen, Robert I. (Student), San Francisco, Calif.
Owens-Corning Fiberglas Corp. (F. V. Tooley), Newark, Ohio
Owens-Illinois Glass Co. (W. A. Mahaffy), 601 36th Ave., Oakland 1, Calif.
Owens-Illinois Glass Co. (E. W. Summers), General Engr. Dept., Alton, Ill.

Pacific Clay Products (Roy Lacy), Box 145, Sta. A, Los Angeles 31, Calif.
Pacific Coast Borax Co. (F. T. Winters), 51 Madison Ave., New York 10, N. Y.
†Packman, Willard D., 1145 Confer Ave., Johnstown, Pa.
Paddock, Laura S., Rowantrees Kiln, Blue Hill, Maine
Paden City Pottery Co. (Merrill C. Sondles), Paden City, W. Va.
Pafford, Ray W., Acme Brick Co., 321 Neil P. Anderson Bldg., Fort Worth 2, Texas
Palmer, Joseph D., 228 Fifth St., Niagara Falls, N. Y.
Palmer, Rufus N., Mellon Inst., 5th Ave., Pittsburgh 13, Pa.
Palmer, W. E., Taylor, Smith & Taylor Co., Chester, W. Va.
Palmer, Willard E., Box 663, Fisher Ave., East Liverpool, Ohio
Paper Makers Importing Co., Inc. (Charles Brian), 640 North 13th St., Easton, Pa.
Paquette, Cyril T., 315 W. Pulteney St., Corning, N. Y.
Park, Frank A., Jr., 309 E. Boyles Ave., New Castle, Pa.
Parker, Charles J., Corning Glass Works, Corning, N. Y.
Parker, Harry (Student), Box 72, Irving, N. Y.
†Parkhurst, Howard M., General Refractories Co., 1407 Oliver Bldg., Pittsburgh 22, Pa.
Parks, Miss Cornelia C., 307 Swarthmore Rd., Glassboro, N. J.

Parmelee, Clifford H., 214 Warham St., Syracuse 8, N. Y.
*†Parmelee, C. W. (Life), Univ. of Illinois, Urbana, Ill.
Parnham, H., General Refractories, Ltd., Worksop, England
Parry, William, Bolton, England
Parsons, Joseph R., 1253 Diversey Parkway, Chicago 14, Ill.
†Pask, Joseph A., Research Dept., Lamp Div., Westinghouse Electric & Mfg. Co., Bloomfield, N. J.
Pasquier, A. L., Franklin Glass Corp., Box 150, Butler, Pa.
Pass & Seymour, Inc. (R. H. Pass), Solvay, N. Y.
Pass, James S., 1636 James St., Syracuse, N. Y.
Pass, R. H., Onondaga Pottery Co., Syracuse, N. Y.
Patch, James B., 206 Howard St., Millville, N. J.
Pavlish, Arnold E., Battelle Memorial Inst., 505 King Ave., Columbus 1, Ohio
Pavliuchenko, V. I., Soviet Purchasing Commission, 210 Madison Ave., New York, N. Y.
Paxton, E. W., Mississippi Glass Co., Main and Angelica Sts., St. Louis 7, Mo.
Pearce, Charles S., The American Ceramic Society, Inc., 2525 N. High St., Columbus 2, Ohio
Pearch, William M., Akron Porcelain Co., Akron 14, Ohio
Pearlman, Sam B., 1027 Metropolitan Ave., Brooklyn, N. Y.
Pearson, E. J. & J., Ltd. (C. W. Thomas), Firebrick Works, Stourbridge, England
Peck, J. Clair, Hanley Co., Summerville, Pa.
Peel, Fred P., 11777 Minden, Detroit 5, Mich.
*Peiler, Karl E., Hartford-Empire Co., Box 1620, Hartford 1, Conn.
Pemco Corp. (Richard Turk), 5601 Eastern Ave., Baltimore 13, Md.
*†Pence, F. K., Div. of Ceramics, Univ. of Texas, Austin, Texas
Pennsylvania Bottle Co. (William Gallagher), Sheffield, Pa.
Pennsylvania Pulverizing Co. (William J. Woods), Box 587, Lewistown, Pa.
Pennsylvania Salt Mfg. Co. (Gertrude Schutze), Whitemarsh Res. Labs., Box 4388, Chestnut Hill Sta., Philadelphia 18, Pa.
Penzickes, John, 63 Mulberry St., Springfield 5, Mass.
Peralta, Hector A., Sidar y Rovirosa 100, Mexico, D. F., Mexico
Pereira, Armando de Arruda, Caixa Postal 1930, São Paulo, Brazil
Pereny, Andrew, 842 N. Pearl St., Columbus, Ohio
Perkins, Harrell L., Central of Georgia Ry., Rhodes-Haverty Bldg., Atlanta 2, Ga.
Perkins, Walter W., 600 De Witt St., Linden, N. J.
Perry, Arthur V. (Student), Randalia, Iowa
Perry, John A. (Student), 801 Colony St., Saskatoon, Saskatchewan, Canada
Perry, Robert F., Victor Insulators, Inc., Victor, N. Y.
Pertuch, Walter A. R., Franklin Inst., Philadelphia 3, Pa.
Peskin, William L., 147 Rossiter Rd., Rochester 7, N. Y.
Petersen, Fred A., Univ. of Illinois, Dept. of Ceramics, Urbana, Ill.
Peterson, L. W., Solvay Process Co., Syracuse 1, N. Y.
Peterson, W. H., M. D. Valentine & Brothers Co., Woodbridge, N. J.
†Petrie, Earl C., North American Refractories Co., National City Bank Bldg., Cleveland, Ohio
Petrie, Lloyd R., 404 W. Snyder St., Abingdon, Ill.
Pettinos, George F., Inc. (George F. Pettinos, Sr.), 1206 Locust St., Philadelphia 7, Pa.
Pettinos, George F., Sr., George F. Pettinos, Inc., 1206 Locust St., Philadelphia 7, Pa.
Petts, Omer F., 2713 Ashland Ave., Baltimore, Md.
Petty, H. E., c/o Andrew Fritsch, R. D. 2, Amherst, Ohio
Pfaudler Co. (O. I. Chormann), Rochester 4, N. Y.
Pfeiff, C. H., Box 527, Metuchen, N. J.
*†Pfeiffer, Wilbur H., Engr. Lab., Plant 2, Frigidaire Div., General Motors Corp., Dayton 1, Ohio
Pfleger, George E., Harshaw Chemical Co., 2424 Enterprise St., Los Angeles, Calif.
Phadake, V. S., Central Potteries, Ltd., Nagpur, India
Phelps, Girard W., United Clay Mines Corp., Trenton 6, N. J.
*Phelps, Stuart M., Mellon Inst., Pittsburgh 13, Pa.
†Phillips, Edwin L., 614 E. Pearl St., Miamisburg, Ohio
Phillips, Gordon D., Olean Tile Co., Olean, N. Y.
†Phillips, James G., Mines Branch, Sussex St., Ottawa, Ontario, Canada
Phillips, William E., Duplate Canada, Ltd., Oshawa, Ontario, Canada
Phillipson, E. G., Box 144, Medicine Hat, Alberta, Canada
Philpot, A. J., British Scientific Instrument Research Assn., 26, Russell Sq., London, W. C. 1, England
Pickard, Henry A., Corona Ave., Antioch, Ill.
Pieper, Arthur O., 105 Trevor Court Rd., Rochester 10, N. Y.
Pierce, D. G., Harshaw Chemical Co., Intelligence Service Div., 1945 East 97th St., Cleveland, Ohio
Pierce, J. Allen, 62 E. Market St., Bethlehem, Pa.
Pierce, Robert H. H., Jr., Research Lab., U. S. Steel Corp., Kearny, N. J.
Piez, Charles W., Jr., Box 408, Aberdeen, Md.
Pike, Robert D., 342 S. Highland Ave., Pittsburgh, Pa.
Pincus, Alexis, American Optical Co., Southbridge, Mass.
Pinney, J. M., Harker Pottery Co., East Liverpool, Ohio
Pinnow, Harley R., Orangeville, Ill.
Pitcairn, William S., 212 Fifth Ave., New York, N. Y.
Pitcock, Lawrence, Crooksville, Ohio
Pitman, Richard D. (Student), 190 North Ave., N. W., Atlanta, Ga.
Pittenger, John T., 9 Park Place, Princeton, N. J.
Pittman, Frank K., Corhart Refractories Co., Inc., 16th & Lee Sts., Louisville 10, Ky.
Pittman, Jack, Box 986, Lewistown, Mont.
Pittsburgh Plate Glass Co., Columbia Chemical Div. (R. W. Miller), Barberton, Ohio
Pittsburgh Plate Glass Co. (C. E. Fulton), Creighton, Pa.
Pittsburgh Plate Glass Co. (A. E. Pye), Columbia Chemical Div., Grant Bldg., Pittsburgh 19, Pa.
†Place, Tom M., 176 Moross Ave., Mount Clemens, Mich.
Plagge, Vernon L., 42 Chestnut St., East Orange, N. J.
†Planje, Christian W., Gladding, McBean & Co., 1275 Harrison St., San Francisco 3, Calif.
Plank, Ross D., 2835 Shadow Lawn Ave., Los Angeles 26, Calif.
Plankenhorn, W. J., Federal Electric Co., 8700 S. State St., Chicago 19, Ill.
Plibrico Jointless Firebrick Co. (W. A. Schaefer), 1840 Kingsbury St., Chicago 14, Ill.
Ploetz, Edwin C. H., Bloomer, Wis.
Pluess, Otto, 1336 First National Bldg., Box 1314, Oklahoma City 1, Okla.
*Plummer, Harry C., Structural Clay Products Inst., 1756 K St., N. W., Washington, D. C.
Plummer, Norman, State Geological Survey of Kansas, Lawrence, Kans.
*†Plusch, H. A., 1014 Oak Lane, Philadelphia 26, Pa.
Plusch, John A., 2 Woodland Terrace, Westfield, Mass.
Polan, Albert, Zenith Optical Co., 832 Court St., Huntington, W. Va.
Polaroid Corp. (D. B. Hummel), 211 Massachusetts Ave., Cambridge, Mass.
†Pole, Gordon R., Box 1525, Wilson Dam, Ala.
Poles, Alfred, 23 Prospect St., Trenton 8, N. J.
Polivka, Jar, 1150 Arch St., Berkeley 8, Calif.
Polk, Arthur E., 3901 S. Morgan St., Chicago 9, Ill.
Pomeroy, W. T., Sterling China Co., East Liverpool, Ohio
Poole, James P. (Student), Dept. of Ceramics, Pennsylvania State College, State College, Pa.
Poor, Mary Eleanor, 28 West 53rd Terrace, Kansas City 2, Mo.
Porcelain Metals Corp. of Louisville (P. B. McBride), 1400 South 13th St., Louisville 10, Ky.
Porcelain Products, Inc. (John G. Loy), Box 300, Findlay, Ohio
Porst, Edward G., 51 E. Randall St., Baltimore, Md
†Porter, Frank R., 318 E. Clark St., Crown Point, Ind.
Porter, Garnett H., 54 Pomeroy Ave., Pittsfield, Mass.
Porter, Rudyard, Carnegie-Illinois Steel Corp., 208 S. LaSalle St., Rm. 1789, Chicago 90, Ill.
Porter, Sidney C., Globe Brick Co., East Liverpool, Ohio

Portsmouth Clay Products Co. (A. C. Judd), Portsmouth, Ohio
†Post, Alfred J. (Student), 1714 Fallowfield Ave., Pittsburgh 16, Pa.
*†Poste, Emerson P., 309 McCallie Ave., Chattanooga 3, Tenn.
Postlewaite, Donald E., Universal Sanitary Mfg. Co., Camden Div., Camden, N. J.
Potters Supply Co. (Dewitt D. Irwin), East Liverpool, Ohio
*Potts, Amos P., 359 E. Main St., Logan, Ohio
Poulton, Robert F., 2763 N. Congress Rd., Camden, N. J.
Powell, Arthur L. (Student), 494 Concord Ave., New York 55, N. Y.
Powell, John A. (Student), 1279 N. Main St., Jamestown, N. Y.
Powell, L. F., Old Hickory Clay Co., Box 271, Paducah, Ky.
Powell, O. E., Indiana Drain Tile Co., Inc., Brooklyn, Ind.
Powell, William J., Plymouth Meeting, Pa.
Power, Henry R., Carborundum Co., Niagara Falls, N. Y.
Power, Laurence E., 136 W. Greenfield Ave., Milwaukee 4, Wis.
Pozefsky, Abbott (Student), Box F-6, Alfred, N. Y.
Pozefsky, Leo (Student), 104 Forest St., Gloversville, N. Y.
Precision Grinding Wheel Co. (George F. Kohn), 8301 Torresdale Ave., Philadelphia, Pa.
Prentice, William J., Jr. (Student), 839 Columbian Ave., Oak Park, Ill.
Presswood, Colin, "Oaklands," Aberaman, Aberdare, Glamorganshire, Wales
Preston, Frank W., Box 847, Butler, Pa.
Price, James E., 5339 Greene St., Philadelphia, Pa.
Price, Lt. Commander P. W., San Francisco, Calif.
Priddy, K. O., Barium Reduction Corp., South Charleston, W. Va.
Priestley, Joseph E., "Desia," Haggstones Rd., Worrall, Sheffield, England
Primm, Herbert E., 103 E. Second St., Los Altos, Calif.
†Prior, Harold D., 55 Orchard Dr., R. D. 1, Lewiston, N. Y.
Proe, Joseph A., Jr., 717 Main St., Niagara Falls, N. Y.
Prokopec, James (Student), 196 West 3rd St., Corning, N. Y.
Promat Div., Poor & Co. (A. E. Chester), 851 S. Market St., Waukegan, Ill.
Prutton, Carl F., Case School of Applied Science, U. C. Sta., Cleveland 6, Ohio
Pryor, Edward K., 5745 Devenshire, Detroit 24, Mich.
Psemeneki, Edward D., 132 West 14th St., Bayonne, N. J.
Pulkingham, W. G., Sovereign Potters, Ltd., Hamilton, Ontario, Canada
Pupulidy, Alexander, Harbison-Walker Refractories Co., Box 357, Chester, Pa.
Purcell, Burnette, Northwestern Terra Cotta Corp., 1750 Wrightwood Ave., Chicago 14, Ill.
*†Purdy, Ross C. (Honorary), The American Ceramic Society, Inc., 2525 N. High St., Columbus 2, Ohio
Purinton Pottery Co. (B. S. Purinton), Shippenville, Pa.
Purinton, B. S., Purinton Pottery Co., Shippenville, Pa.
Pye, A. R., Pittsburgh Plate Glass Co., Columbia Chemical Div., Grant Bldg., Pittsburgh 19, Pa.
Pyro Clay Products Co. (O. E. Miller), Oak Hill, Ohio

Quigley Co., Inc. (R. J. Demaison), 527 Fifth Ave., New York 17, N. Y.
†Quirk, John F., 514 E. Kearsley St., Flint, Mich.

Rabe, N. A., 618 Haddon Ave., Collingswood, N. J.
Rabinowitz, Joel (Student), 640 West 170th St., New York 32, N. Y.
*Radcliffe, B. S., 804 S. Kenilworth Ave., Oak Park, Ill.
†Raine, Frank F., 19 Clifton St., Pittsburgh 10, Pa.
*Ralston, O. C., U. S. Bureau of Mines, Washington 25, D. C.
Ramsden, C. E., C. E. Ramsden & Co., Foley Colour & Chemical Works, Fenton, Stoke-on-Trent, England
Ramtite Co. (Louis J. Jacobs), 2563 West 18th St., Chicago 8, Ill.
Randall, Ruth H., 110 Lynbrook Circle, De Witt, N. Y.
Randolph, Lt. Halfred F., 62 Ridge Rd., Rumson, N. J.
†Rankin, James E., Pine Hall, N. C.
Rankin, James J., Box 97, Monaca, Pa.
Ransome Machinery Co. (J. C. Lukas), Dunellen, N. J.
†Rapp, Carl H., Globe-Union, Inc., 900 E. Keefe Ave., Milwaukee 1, Wis.
Rapp, William, Morton Pottery Co., Morton, Ill.
Ray, John G., 2 E. Sixth St., Emporium, Pa.
Razey, Robert M., 486 Ashland, Detroit 15, Mich.
Rea, Robert F., Universal Zonolite Insulation Co., 2601 West 107th St., Chicago 43, Ill.
Read, Charles W., 205 Hazelcroft Ave., New Castle, Pa.
Read, Edgar B., 6–427 Massachusetts Inst. of Tech., Cambridge 39, Mass.
Reagan, Cornelius J. (Student), Phi Sigma Kappa, State College, Pa.
Redlich, Paul L., 562 Washington Blvd., Chicago, Ill.
Reed, Carl E., 1326 E. Main St., Lancaster, Ohio
Reed, F. E., Glass Co., 860 Maple St., Rochester, N. Y.
Reed, H. M., 106 Dixon Ave., Ben Avon, Pa.
†Reed, Herold N., 416 W. Laurel St., Willard, Ohio
Reed, Paul H. (Student), Hegins, Pa.
Reese, L. P., Scio-Ohio Pottery Co., Scio, Ohio
Refractory & Insulation Corp. (Christopher Branda), Port Kennedy, Pa.
Reid, Harry F., Jr., 233 W. King Ave., Columbus 1, Ohio
Reid, John H. (Student), 65 Kingsway Crescent, Toronto, Ontario, Canada
†Reid, John O., Box 273, Alfred, N. Y.
Reider, K. G., General Electric Co., Nela Park, East Cleveland, Ohio
Reif, Richard E., 62 Washington Ave., Box 289, Berlin, N. J.
Reik, Richard, 212 Carmel Ave., Piedmont 11, Calif.
†Reimer, John J., Box 226, Alfred, N. Y.
Reimers, John C., Pfaudler Co., Taylor St., Elyria, Ohio
Reinker, Gerald E., Glass Technology Lab., 1133 East 152nd St., Cleveland, Ohio
Reiss, Pvt. Max S., Fort McClellan, Ala.
Remington, Victor H., Box 519, Washington, Pa.
*Remmey, G. Bickley, Richard C. Remmey Son Co., Hedley St. and Delaware River, Philadelphia, Pa.
Remmey, John G., Richard C. Remmey Son Co., Hedley St. and Delaware River, Philadelphia, Pa.
Remmey, Richard C., and Son Co. (G. Bickley Remmey), Hedley St. and Delaware River, Philadelphia, Pa.
Remy, Marc E. de B., 365 Redfern Ave., Westmount, Quebec, Canada
Republic Steel Corp. (L. D. Mercer), Republic Bldg., Cleveland 1, Ohio
Resek, Stephen, 1064 Woodbury Rd., New Kensington, Pa.
Reuter, Malvern M., 1600 Alum Creek Dr., Columbus 9, Ohio
Reynolds, Cpl. Owen J., Camp Pickett, Va.
Rhea, Walter A., Box 206, Alpena, Mich.
Rhodes, Daniel, 192 Oak Court, Palo Alto, Calif.
Rhodes, Foster T., Onondaga Pottery Co., Syracuse, N. Y.
Rhodes, Ralph E., Jr. (Student), Oakfield, N. Y.
†Rhodes, Ralph R., 1729 Powell St., Norristown, Pa.
*†Rice, Bryan A., 210 Hollywood Ave., Rochester, N. Y.
Rice, George A., 560 East 120th St., Cleveland 8, Ohio
Rice, Hal H. (Student), Westinghouse Electric & Mfg. Co., Research Labs., East Pittsburgh, Pa.
Rice, Murray J., 133 N. Main St., Alfred, N. Y.
Richardson, H. K., Westinghouse Lamp Div., Westinghouse Electric & Mfg. Co., Bloomfield, N. J.
†Richmond, J. C., 4520 43rd Place, N. W., Washington 16, D. C.
Ricker, Richard W., Libbey-Owens-Ford Glass Co., Vitrolite Div., Parkersburg, W. Va.
Riddell, W. A., Co. (L. A. Henderson), Bucyrus, Ohio
*†Riddle, Frank H., 1420 Strathcona Dr., Detroit 3, Mich.
Riddle, Robert F., 1801 Arrott Bldg., Pittsburgh 22, Pa.

Riegger, Harold E., C. P. S. Camp 94, Trenton, N. Dak.
Riehl, W., Hanovia Chemical & Mfg. Co., Chestnut St. and N.J.R.R. Ave,, Newark 5, N. J.
Rieke, Reinhold (Honorary), Royal Porcelain Factory, Berlin, Germany
*Ries, H. (Honorary, Charter Life), 401 Thurston Ave., Ithaca, N. Y.
Rigterink, Merle D., Bell Telephone Labs., Murray Hill, N. J.
Riis, 'Asgeir, Robeson Process Co., 500 Fifth Ave., New York 18, N. Y.
Riley, W. G., John Walsh Walsh, Ltd., Soho & Vesta Glassworks, Birmingham 18, England
Rindone, Guy E., 418 A Lafayette St., Salem, Mass.
Rippie, C. W., Diamond Alkali Co., Research and Development Labs., Painesville, Ohio
Ritter, Joseph S., Adamston Flat Glass Co., Clarksburg, W. Va.
Roberts, Arthur H., 1208 Eastern Parkway, Brooklyn, N. Y.
Roberts, William, John G. Stein & Co., Ltd., Manuel, near Linlithgow, Scotland
Robertson, Campbell, E. I. du Pont de Nemours & Co., Inc., Perth Amboy, N. J.
Robertson, Leon F., 900 Main St., Brockway, Pa.
Robertson, Randal K., 906 University Tower Bldg., Montreal, Quebec, Canada
Robeson Process Co. ('Asgeir Riis), 500 Fifth Ave., New York 18, N. Y.
Robinson, Alfred W., 2624 East 77th St., Chicago 49, Ill.
Robinson, Gilbert C., Church St., Cooleemee, N. C.
†Robinson, G. R., 224 Mound St., Logan, Ohio
Robinson, Louis G., Louis G. Robinson Labs., Box 167, Cincinnati 1, Ohio
Robinson, Phillip, 26 E. Crescent St., McMahons Pt., Sydney, N. S. W., Australia
Robinson, Radcliffe F., 377 S. Warren Ave., Columbus 4, Ohio
Robinson, Robert R., Robinson Ventilating Co., Zelienople, Pa.
Robinson Ventilating Co. (Robert R. Robinson), Zelienople, Pa.
Robson, H. L., Box 56, Lewiston, N. Y.
*†Robson, James T., Allied Engr. Co., 4150 East 56th St., Cleveland, Ohio
*Roche, Louis C., Maryland Glass Corp., 2143 Wicomico St., Baltimore 30, Md.
Rochow, W. F., Harbison-Walker Refractories Co., Pittsburgh 22, Pa.
Rodefer, H. H., Box 550, Bellaire, Ohio
Rodgers, Joseph P., Seaboard Feldspar Co., 4214 Connecticut Ave., Baltimore, Md.
Rodgers, Rand, Alton Brick Co., Alton, Ill.
Rodman, Clarence J., Box 809, Alliance, Ohio
Rodriguez, Antonio R., Eagle Grinding Wheel Co., 2519 Fulton St., Chicago, Ill.
Rodriguez, Carlos E., Calle de Cuba x Chile 59–1, Medellin, Colombia
*†Roehm, Victor J., 2320 Ridgewood Ave., Alliance, Ohio
Roff, W. Wallace, 14 Glenside Dr., West Orange, N. J.
Rogers, Edwin J., 505 King Ave., Columbus 1, Ohio
Rogers, Gregory L., 2901 Los Feliz Blvd., Los Angeles 26, Calif.
Rolke, Herbert J., Sociedade de Engenharia Industrial, Rua Marconi, 23, 8° andar, São Paulo, Brazil
Rollason, E. C., Murex Welding Processes, Ltd., Hertford Rd., Waltham Cross, Hertfordshire, England
†Rollfs, Edward H., 17838 Commercial Ave., Lansing, Ill.
Rollins, K. Warren, Quimby, Iowa
Rolph, Thomas W., Holophane Co., Inc., Newark, Ohio
Rook, Lt. Edgar J., Jr., San Francisco, Calif.
Rookwood Pottery (H. Leslie Moody), Mount Adams, Cincinnati 2, Ohio
Rose, Charles R., 80 Burt St., Apt. 2, Columbus 3, Ohio
Rose, Ralph, 42 Orchard Lane, Columbus 2, Ohio
*Rosenberg, Jacob E., 789 Academy Place, Pittsburgh 16, Pa.
Roseville Pottery, Inc. (Robert P. Windisch), Zanesville, Ohio
*†Ross, Donald W., 6926 Pineway, Hyattsville, Md.
Rossell, H. A., West Paris, Maine
Rossetti, Jose, Rua Joaquim Nabuco 107, São Caetano S. P. R., São Paulo, Brazil
Ross-Tacony Crucible Co. (K. E. Buck), Tacony, Philadelphia 35, Pa.
Roth, H. A., Rundle Mfg. Co., 3905 River Ave., Camden, N. J.
Rothermel, Joseph J. (Student), 14 Granger Place, Rochester, N. Y.
Roudabush, Douglas E., 3415 38th St., N. W., Washington 16, D. C.
†Roup, Rolland, 4023 N. Larkin St., Milwaukee 11, Wis.
Rowland, Lt. R. A., Ballistic Research Lab., Aberdeen Proving Ground, Md.
Rowland, Roger W., New Castle Refractories Co., New Castle, Pa.
Royal China, Inc. (W. H. Hebenstreit), Sebring, Ohio
Royal, Herbert F., 8525 Butler Ave., Detroit 11, Mich.
Rudisill, William A., 229 Chapman Place, Elmira, N. Y.
†Rue, Charles V. (Student), Box 428, Georgetown, Ontario, Canada
Rueckel, W. C., Koppers Co., Koppers Bldg., Pittsburgh 19, Pa.
Rugh, Frank A., Jr. (Student), 205 N. Second St., Jeannette, Pa.
Rulon, Richard M., 54 S. Franklin St., Lancaster, Pa.
Rundle Mfg. Co. (M. A. Dantzler), 3305 W. Forest Home Ave., Milwaukee 7, Wis.
Rupp, E. M., 410 Northridge Rd., Columbus 2, Ohio
Ruprecht, Bertram C., 4719 Barlind Dr., Pittsburgh 10, Pa.
Rushmore, Murray, Moore & Munger, 33 Rector St., New York 6, N. Y.
Russell, Howard F., Lawrence Clay Co., Jackson, Ohio
*†Russell, Ralston, Jr., Research Labs., Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa.
Russell, Robert G., 293 Buckingham St., Newark, Ohio
Rust, Ellsworth M., 902 Denrike Bldge., 1010 Vermont Ave., N. W., Washington 5, D. C.
Rust, Vernon N., 3601 Santa Fe Ave., Los Angeles, Calif.
Rustless Iron Co., Ltd. (H. Whitaker), Trico Works, Keighley, England
Ryan, Joseph D., 3018 Middlesex Dr., Toledo 6, Ohio
Ryland, Harold W., 1701 Washington Ave., Golden, Colo.
Rynders, Gerald F. (Student), 109 Glen Ave., Elmira, N. Y.

Sada, Pablo M., Box 44, Piedras Negras, Coahuila, Mexico
Sada, Roberto G., Jr., Verlaine 702, Colonia Obispado Monterrey, N. L., Mexico
Safety Grinding Wheel & Machine Co., Box 746, Springfield, Ohio
Safford, Hurd W., Dept. of Chemistry, Univ. of Pittsburgh, Pittsburgh 13, Pa.
Salem China Co. (F. W. McKee), Salem, Ohio
Salisbury, Bert E., Onondaga Pottery Co., 1858 W. Fayette St., Syracuse 4, N. Y.
Salisbury, William R., 209 Standish Dr., Syracuse 3, N. Y.
Sammons, Frederick C., General Refractories Co., 3363 Fruitland Rd., Los Angeles 11, Calif.
Sanborn, Paul H., Porcelain Products, Inc., Parkersburg, W. Va.
Sanders, Clyde A., American Colloid Co., 363 W. Superior St., Chicago, Ill.
Sanderson, Capt. W. R., Box 1425, Area "A," Wright Field, Dayton, Ohio
Santmyers, George S., 812 Washington Dr., Bellevue, Pittsburgh 2, Pa.
†Santomieri, S. Lewis, 701 Kennebec Ave., Takoma Park 12, Md.
Sarraf, Edward M., 20001 Laurel Ave., Rocky River 16, Ohio
Sauereisen, C. Fred, Sharpsburg Sta., Pittsburgh 15, Pa.
Saunders, Alfred C. (Student), 324 E. Chestnut St., East Rochester, N. Y.
Savannah Kaolin Co. (F. H. Opper), 314 American Bldg., Box 184, Savannah, Ga.

Savell, Fred H., 1901 E. Slauson Ave., Los Angeles 11, Calif.
Sawyer, Charles B., 3714 Chester Ave., Cleveland, Ohio
Sawyer, Lt. John P., Jr., c/o Mrs. T. S. Robertson, Belcross, N. C.
Saxe, Charles W., 1 Wawecus Rd., Worcester 5, Mass.
Saxonburg Potteries (George H. Aderhold), Saxonburg, Pa.
Saxton, C., Spotswood, Moor Park Rd., Northwood, Middlesex, England
Scammell, Cpl. R. W. (Student), Ft. Lewis, Wash.
Schabacker, H. E., Erie Enameling Co., 1400 West 20th St., Erie, Pa.
Schaefer, Carl F., 528 East St., Flint 3, Mich.
Schaefer, W. A., Plibrico Jointless Firebrick Co., 1840 Kingsbury St., Chicago 14, Ill.
Scharfenaker, Ensign William J., 333 Brown Hall, Section 122, Naval Training School, Princeton, N. J.
Schaulin, George M., 288 Sundale Rd., Akron, Ohio
Sceiefferle, James A., 2320 Union Ave., Wesleyville, Pa.
Schier, Edwin, Univ. of New Hampshire, Durham, N. H.
Schlake, William E. (Student), 4455 N. Sacramento Ave., Chicago, Ill.
Schlegel, Roland F., Caixa Postal 2948, São Paulo, Brazil
†Schlehr, W. R., Demuth Glass Works, Inc., Parkersburg Div., Box 629, Parkersburg, W. Va.
Schlientz, Major Donald T., New York, N. Y.
Schloffman, Lt. J. Paul, New York, N. Y.
Schmeisser, Clarence E., 2701 South 7th St., Ironton, Ohio
Schmid, Arthur W., Suite 1214, Investment Bldg., 239 Fourth Ave., Pittsburgh 22, Pa.
Schmidt, Buether L., Anchor Hocking Glass Corp., Lancaster, Ohio
Schoeninger, Irvin W., 5250 N. Shoreland Ave., Milwaukee 11, Wis.
Schoenlaub, Robert A., Basic Refractories, Inc., Maple Grove, Ohio
†Schoeppel, Norman, 417 E. Jackson St., Mexico, Mo.
*†Schofield, H. Zane, Battelle Memorial Inst., 505 King Ave., Columbus, Ohio
Scholes, Addison B., 67 Adams St., Danvers, Mass.
*Scholes, S. R., N. Y. State College of Ceramics, Alfred, N. Y.
†Scholes, William A., 18930 Littlefield Ave., Detroit 21, Mich.
†Schory, R. M., North Market St., Minerva, Ohio
Schottland, A. H., Standard Bent Glass Co., Butler, Pa.
*Schramm, Edward, Onondaga Pottery Co., Syracuse 4, N. Y.
Schreckengost, Don, 4 Park St., Alfred, N. Y.
Schreckengost, Viktor, 2366 Noble Rd., Cleveland 21, Ohio
*†Schroeder, Fred W., Box 105, Warrenton, Mo.
Schuh, Arthur E., United States Pipe and Foundry Co., Burlington, N. J.
Schundler, F. E., & Co., Inc. (C. P. Derleth), Box 1145, Joliet, Ill.
*†Schurecht, H. G., Champion Spark Plug Co., 8525 Butler Ave., Detroit 11, Mich.
*Schurtz, D. D., Sharp-Schurtz Co., Lancaster, Ohio
Schutze, Gertrude, Pennsylvania Salt Mfg. Co., Whitemarsh Research Labs., Box 4388, Chestnut Hill Sta., Philadelphia 18, Pa.
Schwab, Leon B., 416 N. Main St., Vandalia, Mo.
Schwalbe, F. G., Box 250, Sta. B, Toledo, Ohio
Schwartz, Murray A., 223 Hawthorne Ave., Yonkers, N. Y.
Schwartz, W. D., L. H. Butcher Co., 2030 Bay St., Los Angeles, Calif.
*†Schwartzwalder, Karl, 2150 Rattalee Lake Rd., Holly, Mich.
Schwarz, E. A., Crunden Martin Mfg. Co., 760 South 2nd St., St. Louis 2, Mo.
Schweiker, Malcolm A., Jr. (Student), Worcester, Pa.
Schweitzer, Howard V., Schweitzer Equipment Co., 306 Chester-Twelfth Bldg., Cleveland, Ohio
†Schwendler, Richard H., Jackson St., Mentor, Ohio
Schwetye, Fred H., Vandalia, Mo.
†Scott, M. R., Bausch & Lomb Optical Co., Rochester 2, N. Y.
Scott, Roger F., 911 E. Main St., Millville, N. J.
Scott, W. J., 319 N. Washington St., Hinsdale, Ill.
Scripture, C. P., Ingram-Richardson Mfg. Co. of Indiana, Inc., Frankfort, Ind.
Seabright, Edward C., 418 Manistique, Detroit 15, Mich.
Seanor, J. G., 2300 W. Tuscarawas St., Canton 6, Ohio
Searle, A. B., Charlbury, Oxon, England
Searson, Leslie, James Oakes & Co. (Riddings Collieries), Ltd., Jacksdale, Nottinghamshire, England
*Seaton, Max Y., United Chemicals, Inc., 405 Lexington Ave., New York 17, N. Y.
Seaver, Kenneth, Harbison-Walker Refractories Co., 1800 Farmers Bank Bldg., Pittsburgh 22, Pa.
Seeley, E. L., Neptune Ave., Chester, W. Va.
Segeler, C. G., American Gas Assn., 420 Lexington Ave., New York 17, N. Y.
Seibert, Leslie W. (Student), 1101 W. Pennsylvania Ave., Urbana, Ill.
*†Seil, Gilbert E., Day & Zimmermann, Inc., Packard Bldg., Philadelphia 2, Pa.
Sellers, George A., 1036 S. Harvey Ave., Oak Park, Ill.
†Sellers, John T., 210 N. Pennsylvania Ave., Wellston, Ohio
Seneca Glass Co. (Harry J. Sigwart), Morgantown, W. Va.
Sessler, Matt, 2323 West 3rd St., Cleveland 13, Ohio
Sewell, Nathan R. (Student), 231 Dauphine St., East Point, Ga.
†Shaffer, Paul C., 126 Crawford Ave., Altoona, Pa.
Shand, Errol B., 168 Pine St., Corning, N. Y.
Shank, Jacob R., Engr. Expt. Sta., Ohio State Univ., Columbus, Ohio
Shank, John J., Wayne Labs., 17 E. Main St., Waynesboro, Pa.
Shanks, Douglas, Victorian Pottery, Barrhead, near Glasgow, Scotland
Shapiro, Lt. Joseph K., 1710 Andrews Ave., Bronx, N. Y.
Shardlow, L. Russel, RCA Victor Div., Radio Corp. of America, Harrison, N. J.
*Sharp, Donald E., Libbey-Owens-Ford Glass Co., Toledo 5, Ohio
†Sharp, Everett W., 827 N. Calhoun, Mexico, Mo.
Shattuck, Lucille, Rm. 636, Mills Bldg., San Francisco, Calif.
Shaver, W. W., 214 Wall St., Corning, N. Y.
*Shaw, J. B., 5402 13th St., N. W., Washington 11, D. C.
Shaw, L. I., 7420, Western Electric Co., Hawthorne Sta., Chicago 23, Ill.
*†Shaw, M. C., CERACAP Associates, Metuchen, N. J.
Shaw, Ronald H., L. E. Shaw, Ltd., Halifax, Nova Scotia
Shayler, Pfc. Lewis E., St. Petersburg, Fla.
Shearer, Walter L., 45 Ridge Ave., Morrisville, Pa.
*Sheerer, Mary G., 2508 Auburn Ave., Cincinnati 19, Ohio
Sheldon, John L., 112 E. Third St., Corning, N. Y.
Sheldon, Robert E., 3039 Wallace Ave., Bronx 67, N. Y.
Shelley, Cranson B., General Refractories Co., Box 1673, Baltimore, Md.
*Shelton, G. R., 6614 Delfield St., Chevy Chase, Md.
Shenango Pottery Co. (James M. Smith), New Castle, Pa.
Shepard, Anna O., 751 11th St., Boulder, Colo.
Shepherd, John F., Shepherd Chemical Co., Norwood, Cincinnati 12, Ohio
Sherwin, Ronald W., H. R. Johnson, Ltd., Tunstall, Staffordshire, England
Sherwood, Laurence T., Pennsylvania Wire Glass Co., Dunbar, Pa.
*†Sherwood, Robert F., United Feldspar & Minerals Corp., 10 East 40th St., New York 16, N. Y.
Shevlin, Thomas S. (Student), 34 Military Post, Fort Thomas, Ky.
Shimer, J. B., 16 Grant St., Wellsboro, Pa.
Shimman, Norman C., 19175 Pierson St., Detroit 19, Mich.
Shipley, Linden E., Messrs. Mobberley & Perry, Ltd., Stourbridge, Worcestershire, England
Shipley, R. A., National Fireproofing Corp., 202 E. Ohio St., N. S., Pittsburgh, Pa.
*Shively, R. R., Chartiers St., Washington, Pa.
Shoemaker, George, Arketex Ceramic Corp., Brazil, Ind.

Shoenberger, Horace K., 542 Mahoning St., Lehighton, Pa.
†Shonkwiler, Francis P., 4211 W. Hill Ave., N. D. G., Montreal, Quebec, Canada
Shook, Thurston W., 845 Hanna Bldg., Cleveland, Ohio
Short, A. C., 36 Hull Ave., St. Vital, Winnipeg, Manitoba, Canada
Short, Allan M., 1710 Missouri Pacific Bldg., St. Louis 3, Mo.
Short, Albert P., Charles Taylor Sons Co., 401 N. Broad St., Philadelphia 8, Pa.
Shorter, A. J., Bonnybridge Silica & Fireclay Co., Ltd., Bonnybridge, Stirlingshire, Scotland
†Shukle, Archie A., 1313 Washington Ave., Flint, Mich.
Shuman, Albert, 1819 Broadway, New York 23, N. Y.
Shute, Robert L., 125 N. Twenty-first St., Newark, Ohio
Siefert, August C., 292 Hudson Ave., Newark, Ohio
Siegwald, Clyde R., Upland Ave., Arbutus Park, Park, W. Va.
Sierra Talc Co. (E. J. Ellsworth), 500 Union League Bldg., Los Angeles 12, Calif.
Sievert, Guilio E., 8169 San Antonio, South Gate, Calif.
Sigwart, Harry J., Seneca Glass Co., Morgantown, W. Va.
Silk, Karl, Jury Holloware, Ltd., Sandy Rd., Norton, Stourbridge, England
*†Silverman, Alexander, Dept. of Chemistry, Univ. of Pittsburgh, Pittsburgh 13, Pa.
Silverman, William B., Owens-Illinois Glass Co., 1700 Westwood Ave., Toledo 1, Ohio
†Simison, A. L., Owens-Corning Fiberglas Corp., Newark, Ohio
Simmonds Aerocessories, Inc. (J. E. D. McCarty), 21–140 49th Ave., Long Island City, N. Y.
Simmons, Robert M., 3269 Casitas Ave., Los Angeles 26, Calif.
Simon, A. G., 3014 Piedmont Ave., La Crescenta, Calif.
Simonds Worden White Co. (F. R. Henry), North Summit St. and Negley Place, Dayton 7, Ohio
Simonsen, Victor G., Ceramica São Caetano, S. A., Caixa Postal 278, São Paulo, Brazil
Simpson, Ernest, Highview Fenton Manor, Stoke-on-Trent, Staffordshire, England
†Simpson, Harold E., Mellon Inst., Pittsburgh 13, Pa.
*Singer, Felix, Keramos House, 46, Castlemaine Ave., South Croydon, Surrey, England
Sirovy, George, 6643 S. Narragansett Ave., Chicago 38, Ill.
Sixt, Lawrence F., 438 E. Winter Ave., New Castle, Pa.
Sjostrőm, Ivar, Höganäs-Billesholms Aktiebolag, Höganäs, Sweden
Skeoch, Walter K., 320 S. Mission Rd., Los Angeles 33, Calif.
†Skinner, Kenneth G., 3207 Franklin Ave., Seattle 2, Wash.
Skoog, Harold O., American Emery Wheel Works, 1 Richmond Sq., Providence, R. I.
Slayter, Games, Owens-Corning Fiberglas Corp., Newark, Ohio
Slick, E. E., Haws Refractories Co., 407 Main St., Johnstown, Pa.
Slick, E. E., Sr., Farmers Bank Bldg., Pittsburgh 22, Pa.
†Slyh, John A., National Carbon Co., Fostoria, Ohio
Smiley, William D. (Student), Phi Gamma Delta, State College, Pa.
Smith, A. O., Corp. (W. W. Higgins), 3533 North 27th St., Milwaukee, Wis.
Smith, Bernard C., 421 2nd Ave., S. W., Le Mars, Iowa
Smith, C. A., Mexico Refractories Co., Mexico, Mo.
†Smith, Charles A., 326 Woodlawn, Mexico, Mo.
Smith, Donald I., Denver Fire Clay Co., Denver 2, Colo.
Smith, Donald R., 2724 South 7th St., Ironton, Ohio
Smith, Dudley C., 901 Landis Ave., Vineland, N. J.
Smith, Edwin G., 441 Old Farm Rd., Mount Lebanon, Pa.
Smith, E. H., Paper Makers Importing Co., Inc., Box 361, Lisbon, Ohio
Smith, Frank A., R. D. 1, Box 481, Lafayette, Calif.
Smith, F. E., Harris Clay Co., Spruce Pine, N. C.
Smith, F. Goodwin, Hartford-Empire Co., Box 1620, Hartford, Conn.
Smith, Gail P., Box 158 A, R. D. 1, Corning, N. Y.
Smith, G. Frederick, Chemistry Dept., Univ. of Illinois, Urbana, Ill.
†Smith, Hillard A., 59 Walnut Place, Metuchen, N. J.
Smith, H. P., Joseph Dixon Crucible Co., Jersey City, N. J.
Smith, James M., Shenango Pottery Co., New Castle, Pa.
Smith, James N., Jr., 142 Pollock St., New Bern, N. C.
Smith, J. Ernest, 1351 Marlborough Ave., Plainfield, N. J.
Smith, J. Talbot, c/o Walter E. Smith, 33 S. Valley Ave., Vineland, N. J.
Smith, Karl W. S., Charles Taylor Sons Co., Cincinnati 14, Ohio
*†Smith, Kenneth E., 6926 Willow St., New Orleans, La.
Smith, Kenneth M., Box 53, Pikesville 8, Md.
Smith, Leland, Acme Brick Co., Box 708, Denton, Texas
Smith, Louis A., Jones & Laughlin Steel Corp., Aliquippa, Pa.
Smith, Maurice A., II, Jeannette, Pa.
Smith, Paul L., Sound Div., Naval Research Lab., Washington, D. C.
Smith, Ralph O., 30 Chestnut St., Salem, N. J.
Smith, R. Jack, Jr. (Student), 16 Horne St., Raleigh, N. C.
Smith, R. K., 149 Reynolds Ave., Corning, N. Y.
Smith, Robert A., 3450 Pine Grove Ave., St. Louis 20, Mo.
Smith, Rowland D., 12 Woodlawn Ave., Corning, N. Y.
Smith, Russell C., 713 North 37th St., East St. Louis, Ill.
Smith & Stone, Ltd. (B. Stone), Georgetown, Ontario, Canada
Smith, Walter T., 30 Austin St., New Haven 15, Conn.
Smith, Wendell O., Corning Glass Works, Corning, N. Y.
Smith, Wilbur R., 2126 Kennedy St., Philadelphia 24, Pa.
Smock, Alden W., 248 E. Fourth St., Corning, N. Y.
Smoke, Joseph E., 29 Bissett Place, Metuchen, N. J.
Smoot, Jack M., 323 Rogers Ave., Macon, Ga.
Smothers, William J. (Student), 214 Timkler, Lafayette, Ind.
Smyth, Harold T., Corhart Refractories Co., Inc., Louisville 10, Ky.
Snelsire, W. P., Pennsylvania Salt Mfg. Co., 541 Union Trust Bldg., Pittsburgh 19, Pa.
Snodgrass, Howard O., 908 S. Elm, Villa Grove, Ill.
Snow, Roland B., Research Lab., United States Steel Corp., Kearny, N. J.
†Snyder, Ernest B., Apt. 15, 716 6th Ave., Bethlehem, Pa.
Snyder, F. Edward (Student), West Decatur, Pa.
Snyder, Nicholas H., National Ceramic Co., 400 Southard St., Trenton 2, N. J.
Snyder, Ray A., Stupakoff Ceramic & Mfg. Co., Latrobe, Pa.
Snyder, R. B., Bell & Howell Co., 7100 McCormick Blvd., Chicago 45, Ill.
Society of Glass Tech., W. E. S. Turner, "Elmfield," Northumberland Rd., Sheffield 10, England
*Sohn, Erwin, American Radiator & Standard Sanitary Corp., 1541 South 7th St., Louisville 8, Ky.
*†Solèr, Gilbert, Steel & Tube Div., Timken Roller Bearing Co., Canton 6, Ohio
†Solomon, Earl A., 32 Sickmon St., Hamburg, N. Y.
Solvay Process Co. (L. W. Peterson), Syracuse 1, N. Y.
Somers, A. J., Borax Consolidated, Ltd., Danes Hill, Oxshott, Surrey, England
Somerville, Thomas, III, 130 Brookside Dr., Chevy Chase, Md.
†Sommerville, J. L., Winburne, Pa.
Sondles, Merrill C., Paden City Pottery Co., Paden City, W. Va.
Soper, George A., Jr., McLeod & Henry Co., Inc., 357 First St., Troy, N. Y.
*†Sosman, Robert B., U. S. Steel Corp., Research Lab., Lincoln Highway, Kearny, N. J.
South, Furman, Jr., Lava Crucible Co. of Pittsburgh, 627 Wabash Bldg., Pittsburgh, Pa.
Sovereign Potters, Ltd. (W. G. Pulkingham), Hamilton, Ontario, Canada
Sparks, Edgar W., 406 Unaka Way, Erwin, Tenn.
Sparler, D. J., Universal Asbestos Corp., 87–41 130th St., Richmond Hill, N. Y.

Sparrow, Paul F., 610 Shady Dr., E., Pittsburgh 16, Pa.
Speil, Sidney, Norris, Tenn.
Spence, Harold I., R. D. 4, Box 553, Stockton, Calif.
Spence, Hugh S., Industrial Minerals Div., Bureau of Mines, Ottawa, Ontario, Canada
*Spencer, Charles D., General Electric Co., 1133 East 152nd St., Cleveland 12, Ohio
Spencer, Ernest H., Friendship, N. Y.
*†Spencer-Strong, G. H., 4134 Westview Rd., Baltimore 18, Md.
Spengler, H. H., Mahoning Glass Works, Niles, Ohio
Spikes, W. F., Dept. 817, Sears Roebuck & Co., 925 S. Homan Ave., Chicago 7, Ill.
Spinks, H. C., Clay Co. (R. B. Carothers), Box 256, Newport, Ky.
†Spires, Stephen T., North American Refractories Co., Mt. Union, Pa.
Spooner, E. C. R., Magnesium Metal Corp., Ltd., Port Tennant Works, Swansea, South Wales
Spring, F. W., Metters, Ltd., Mitchell Rd., Alexandria, Sidney, N. S. W., Australia
*†Sproat, Ira E., Gorham Ave., Westport, Conn.
Square D Co. (H. S. Freeman), 6060 Rivard St., Detroit, Mich.
Stafficker, Charles F., 8th St. and Park Ave., Vineland, N. J.
Stafford, Edward F., Patterson Heights, Beaver Falls, Pa.
†Stafford, W. L., Johns-Manville Research Labs., Manville, N. J.
Stahl, C. B., Sherman St., White Hall, Ill.
Stalego, Charles J., 249 N. Fifth St., Newark, Ohio
Staley, Dean M., 2304 N. Mercer St., New Castle, Pa.
*Staley, Homer F., Metal & Thermit Corp., 120 Broadway, New York 5, N. Y.
Standard Brick & Tile Corp. (H. C. Kleymeyer), Evansville 19, Ind.
Stangl, J. M., Fulper Pottery Co., Flemington, N. J.
Stanko, J. A., 5601 S. Boyle Ave., Los Angeles, Calif.
Stanny, Norbert F., Orefraction, Inc., 7505 Meade St., Pittsburgh 8, Pa.
Stanworth, John E., 24, Ringinglow Rd., Ecclesall, Sheffield, England
Stark, Ira A., 1118 South 2nd St., Louisville, Ky.
Star Porcelain Co. (R. W. Ferguson), Muirhead Ave., Trenton 9, N. J.
Stark Brick Co. (J. H. Stewart), Box 230, Canton, Ohio
Stark, Rawson E., R. D. 5, Greensburg, Pa.
Starkey, Daryle D., 1975 Sixth St., S. W., Akron 14, Ohio
Staudt, August, Perth Amboy Tile Works, Perth Amboy, N. J.
Stauffer Chemical Co., 420 Lexington Ave., New York 17, N. Y.
Steck, C. O., 1 Twenty-eighth St., Pittsburgh, Pa.
Steele, George A., 546 Cedarhurst Ave., Dayton 7, Ohio
Steele, H. D., Shorter & Son, Ltd., Copeland St., Stoke-on-Trent, England
Steel, J. C., Jr., J. C. Steele & Sons, Statesville, N. C.
Steil, Ray C., 1228 Prairie Ave., Des Plaines, Ill.
Stein, Colonel Alan, Millfield, Polmont, Stirling, Scotland
Stein, Beryl (Student), 3408 W. Adams St., Chicago 24, Ill.
Stein, Colin H., 39 Snowdon Place, Stirling, Scotland
Stein, Norman A., Rossmor, Grantown-on-Spey, Scotland
Steinbeck, E. A., Whip-Mix Corp., 411 W. Avery St., Louisville 8, Ky.
Steinbrunn, Herman F., 1348 College Ave., Palo Alto, Calif.
Steiner, Harry C., 518 Sanders Ave., Scotia 2, N. Y.
*†Steinhoff, Fred L., Rm. 1410, 59 E. Van Buren St., Chicago 5, Ill.
*Stephani, William J., O. W. Ketcham Terra Cotta Works, Crum Lynne, Pa.
Stephenson, H. H., Lawrence Clay Co., Jackson, Ohio
Stephenson, S. R., Box 1192, Birmingham, Ala.
Sterling China Co. (W. T. Pomeroy), East Liverpool, Ohio
Sterling Grinding Wheel Co. (A. E. Tulk), Tiffin, Ohio
Stern, Joseph, 64 Cedar Ave., Rockville Center, N. Y.
Stettinius, K. E., Lapp Insulator Co., Inc., Le Roy, N. Y.
Stevens, Lt. Donald K., New York, N. Y.
*Stevens, Douglas F., 1210 W. California Ave., Urbana, Ill.
†Stevens, Frank J., 198 S. Crest Rd., Chattanooga 4, Tenn.
Stevens, Lt. J. E., Camp Atterbury, Ind.
†Stevens, Robert P., Chicago Retort & Fire Brick Co., 208 S. LaSalle St., Chicago 4, Ill.
†Stevenson, James K., Jr., R. D., Mundelein, Ill.
Stewart, Alexander, National Lead Co., 105 York St., Brooklyn, N. Y.
Stewart, Jack, Calle Pericon 14, Cuernavaca, Morelos, Mexico
Stewart, J. G., Braun Corp., 2260 East 15th St., Los Angeles 21, Calif.
Stewart, J. H., Stark Brick Co., Box 230, Canton, Ohio
Stewart, John A., c/o S. E. Stewart, 605 S. Sixth St., Vandalia, Ill.
Stewart, Paul B. (Student), Dept. of Chemical Engr., Univ. of Texas, Austin 12, Texas
Stewart, S. T., 1205 Carlisle St., Tarentum, Pa.
Stickley, E., Pittsburgh Plate Glass Co., Creighton, Pa.
†Stief, W. C., 158 S. Wilson Blvd., Mount Clemens, Mich.
Stockbridge, Charles, 559 Connecticut St., Gary, Ind.
Stockstrom, Arthur, American Stove Co., St. Louis, Mo.
Stoffer, Ross, American Clay Forming Co., Tiffin, Ohio
Stohl, L. A., Wisconsin Porcelain Co., Sun Prairie, Wis.
†Stolte, Norman H., 919 Stilwell Ave., Fremont, Ohio
Stone, B., Smith & Stone, Ltd., Georgetown, Ontario, Canada
Stone, C. P., Ferramic Industries, Ltd., Hydeway, Welwyn Garden City, Hertfordshire, England
Stone, Robert J., John W. Higman Co., 24 State St., New York 18, N. Y.
†Stone, Robert L., Dept. of Ceramic Engr., Univ. of North Carolina, Raleigh, N. C.
Stong, Guy E., Strathmont Park, Elmira, N. Y.
Stookey, Stanley D., 145 Pritchard Ave., Corning, N. Y.
Stott, A. E., Edward Johns & Co., Ltd., Armitage, near Rugeley, Staffordshire, England
Stott, E. E. (Student), 70 Moreland Ave., S. E., Atlanta, Ga.
Stott, Joseph A., 506 Otis Bldg., Philadelphia 2, Pa.
*†Stout, Wilber, 154 Erie Rd., Columbus 2, Ohio
Straight, Capt. Lee H., New York, N. Y.
Stratton, Mrs. W. B., Pewabic Pottery, 10125 Jefferson Ave., Detroit 14, Mich.
Streator Brick Co. (D. P. Ogden), Streator, Ill.
Strikow, M. H., 5064 W. Adams Blvd., Los Angeles 16, Calif.
Stringer, Fred W., 3765 Dover Place, Los Angeles 26, Calif.
Strod, Arved J., Vitro Mfg. Co., Corliss Sta., Pittsburgh, Pa.
Strong, John, 46 Center Ave., Belmont, Boston, Mass.
Stroud, Harold L., 3426 Hunter Ave., Royal Oak, Mich.
Stroup, Philip T., Aluminum Co. of America, Box 772, New Kensington, Pa.
Structural Clay Products Inst. (Harry C. Plummer), 1756 K St., N. W., Washington 6, D. C.
Stuckey, David L., Box 1052, Macon, Ga.
Stuckey, Jasper L., Univ. of North Carolina, Raleigh Unit, Raleigh, N. C.
Stuckey, Robert C., Jr., Box 152, Manasquan, N. J.
Stufft, Paul C., 2802 Inglewood Ave., Baltimore, Md.
Stupakoff Ceramic & Mfg. Co. (Semon H. Stupakoff), Latrobe, Pa.
Stupakoff, Semon H., Stupakoff Ceramic & Mfg. Co., Latrobe, Pa.
Styer, Charles A., 11 Roxbury Rd., Forest Hills, Pittsburgh 21, Pa.
Sugden, John A., "Sharrow," Dunley Rd., Stourport, Worcestershire, England
*Sullivan, E. C., Corning Glass Works, Corning, N. Y.
*Sullivan, John D., 505 King Ave., Columbus 1, Ohio
Summerhays, Louis J., William Summerhays Sons Corp., 620 Clinton Ave., S., Rochester 7, N. Y.
Summers, E. W., Owens-Illinois Glass Co., General Engr. Dept., Alton, Ill.

Summitville Face Brick Co. (H. K. Lynn), Summitville, Ohio
Sumrell, Ferrall N., 223 Henry St., East Hempstead, N. Y.
Sun, Kuan Han, Research Labs., Eastman Kodak Co., Rochester 4, N. Y.
Sur Enamel & Stamping Works, Ltd. (M. M. Sur), 9 Middle Rd. Entally, Calcutta, India
Sur, M. M., Sur Enamel & Stamping Works, Ltd., 9 Middle Rd. Entally, Calcutta, India
Surface Combustion Corp. (Harvey C. Weller), 2375 Dorr St., Toledo, Ohio
Surfleet, Harold, Kaylene Labs., Waterloo Rd., London, N. W. 2, England
Sutherland, J. Clark, Pacific Clay Products, 306 West Ave. 26, Los Angeles 31, Calif.
Sutphen, F. G., American Rolling Mill Co., Middletown, Ohio
Sutterlin, Frederick, Scammell China Co., Trenton 10, N. J.
Sutton, W. J., Alfred, N. Y.
Svec, J. J., 3440 S. Euclid Ave., Berwyn, Ill.
*†Swain, Stephen M., 3403 Spangler Rd., Cleveland Heights 12, Ohio
Swalm, Phaon H., Box 178, Kingston, Ontario, Canada
Swan, S. D., Dentists' Supply Co., 220 West 42nd St., New York 18, N. Y.
Swearingen, J. C., Hazel-Atlas Glass Co., Zanesville, Ohio
*†Sweely, B. T., Chicago Vitreous Enamel Product Co., 1407 South 55th Court, Cicero, Ill.
Sweitzer, Mark, Scio-Ohio Pottery Co., Scio, Ohio
Swenson, George W., Minnesota Mining & Mfg. Co., 900 Fauquier Ave., St. Paul, Minn.
Swentzel, John P., 2725 Weston Ave., Niagara Falls, N. Y.
*Sweo, Benjamin J., Ferro Enamel Corp., 4150 East 56th St., Cleveland, Ohio
Swicker, Victor C., Alexander H. Kerr & Co., Inc., Box 535, Santa Ana, Calif.
Swift, Howard R. (Student), 204 Ceramics Bldg., Univ. of Illinois, Urbana, Ill.
Swift, Roy E., 1327 East 4th, S., Salt Lake City, Utah
Swindell Brothers, Bayard & Russell Sts., Baltimore, Md.
Swindell-Dressler Corp. (Philip Dressler), Box 1888, Pittsburgh 30, Pa.
Swinnerton, Bertram B., 21 Second Ave., Tiffin, Ohio
Swinnerton, George R., 529 Vincent Blvd., Alliance, Ohio
Sylvania Electric Products, Inc. (B. S. Ellefson), 208–20 Cross Island Parkway, Bayside, Long Island, N. Y.
†Sylvester, George R., Sylvester & Co., 1614 Terminal Tower, Cleveland 13, Ohio
Syndicat des Fabricants de Produits Céramiques, Jean Berard, 84 Rue d'Hauteville, Paris, France

Taber, A. W., Charles Engelhard, Inc., 90 Chestnut St., Newark, N. J.
Tait, Leonard G., Cia. Geral de Engenharia para America do Sul, Predio Conde Matarazzo, Rua Dr. Falcao Filho 56, São Paulo, Brazil
†Talbott, Paul T., Potomac, Ill.
Tama, Manuel, Ajax Engr. Corp., Box 1418, Trenton 7, N. J.
Tancous, Ernest, 1319 First Ave., New York, N. Y.
Tapper, Edward A., Davidson Brick Co., 4701 Floral Dr., Los Angeles, Calif.
†Tate, Frank E., 686 W. Ohio Ave., Sebring, Ohio
†Tauber, Charles B. (Student), 2301 Broadway, Catlettsburg, Ky.
†Tauber, John A., 1424 Powell St., Norristown, Pa.
Taylor, A. H., Chicago Retort & Fire Brick Co., 208 S. LaSalle St., Chicago 4, Ill.
Taylor, Charles, Sons Co. (C. R. Taylor), Box 58, Annex Sta., Cincinnati 14, Ohio
Taylor, Charles H., Jr. (Student), San Francisco, Calif.
Taylor, C. R., Charles Taylor Sons Co., Box 58, Annex Sta., Cincinnati 14, Ohio
Taylor, Douglas J., 62 E. Market, Bethlehem, Pa.
*Taylor, Nelson W., Research Dept., Minnesota Mining & Mfg. Co., St. Paul 6, Minn.
Taylor, R. F., Pilkington Brothers, Ltd., St. Helens, Lancashire, England
Taylor, Robert M., Jr., Box 606, Christiansburg, Va.
Taylor, T. J., 1140 Independence Ave., Waterloo, Iowa
Taylor, Smith & Taylor Co. (W. E. Palmer), Chester, W. Va.
*Taylor, W. C., Corning Glass Works, Corning, N. Y.
†Teague, Jo Morgan, Jr., 150 Barksdale Dr., Atlanta, Ga.
*Teetor, Paul, 253 Altamont Place, Somerville, N. J.
*†Tefft, C. Forrest, Claycraft Co., Box 866, Columbus 16, Ohio
Tefft, Philip W., Morrison Rd., Blacklick, Ohio
Tepping, Herbert, 334 Kenwood Ave., Dayton 5, Ohio
Terman, Mark J., Babcock & Wilcox Co., 2730 Koppers Bldg., Pittsburgh 19, Pa.
Terrill, Gerald, McKee Glass Co., Jeannette, Pa.
Terry, Griffin E., Edison General Electric Appliance Co., Inc., 5600 W. Taylor St., Chicago 44, Ill.
Terry, John H., Jr., Farrhill, Westmoreland Depot, N. H.
*Tetrick, James D., 542 Coleman Place, Westfield, N. J.
Texas Mining & Smelting Co. (W. J. Graveling), Box 559, Laredo, Texas
Thatcher Mfg. Co. (Roy S. Arrandale), 1901 Grand Central Ave., Elmira, N. Y.
Theobald, Erwin F., 1516 18th St., N. W., Canton 3, Ohio
*†Thiemecke, Harry W., Homer Laughlin China Co., Newell, W. Va.
*Thiess, L. E., Porcelain Mfg. Div., General Electric Co., Schenectady 2, N. Y.
Thomas, C. W., E. J. & J. Pearson, Ltd., Firebrick Works, Stourbridge, England
Thomas, Major Charles W. (Honorary), Clifton House, Old Swinford, Stourbridge, England
†Thomas, Everett A., 28 Montclair St., Buffalo 15, N. Y.
Thomas, Henry H., Glenarm, Baltimore, Md.
†Thomas, James A., 1142 Niagara Ave., Niagara Falls, N. Y.
Thompson, A. Paul, Mellon Inst., Pittsburgh 13, Pa.
*Thompson, Clyde L., 4922 New Plymouth Rd., Pittsburgh 10, Pa.
Thompson, Franklin S., 25 Schenck Ave., Matawan, N. J.
Thompson, Fred S., Corhart Refractories Co., Inc., 16th and Lee Sts., Louisville 10, Ky.
Thompson, M. W., Hall China Co., East Liverpool, Ohio
Thompson, Noel M., 721 Shady Lane, Pittsburgh 16, Pa.
Thompson, Thomas C., 1419 Central Ave., Wilmette, Ill.
Thomson, Homer G., 211 North 88th St., Wauwatosa 13, Wis.
Thor, Murner E., 508 S. Serrano Ave., Los Angeles 5, Calif.
Thorley, Joseph P., Parkway, East Liverpool, Ohio
Thorn, William J., Innis, Speiden & Co., 401 N. Broad St., Philadelphia, Pa.
Thorngate, Bruce W., Box 2614, University Sta., Gainesville, Fla.
†Thornton, Paul E., 900 N. Howard St., Glendale 7, Calif.
Thornton, R. Allan, Jr., Armstrong Cork Co., Central Technical Lab., Lancaster, Pa.
Thropp, Herreld D., Eureka Flint & Spar Co., Box 266, Trenton 2, N. J.
Thuener, Everett E., 412 Reynolds St., Scotia, N. Y.
Thurn, Haldon L., 709 E. Juneau Ave., Milwaukee 2, Wis.
†Thurnauer, Hans, 1811 Hixson Pike, Chattanooga 5, Tenn.
Thwing, C. B., 45 W. Tulpehocken St., Philadelphia 44, Pa.
Tibbals, Harvey L. (Student), 1911 46th Ave., S. W., Seattle 6, Wash.
Tiebout, C. H., Gleason-Tiebout Glass Co., 59 54th St., Maspeth, N. Y.
Tiede, Ralph L., 268 Elmwood Ave., Newark, Ohio
Tillotson, Clifford, Tillotson Refractories Co., 1112 W. Sixth St., Corona, Calif.
*Tillotson, E. Ward, Mellon Inst., Pittsburgh, Pa.
Tillyer, Edgar D., American Optical Co., Southbridge, Mass.
Tims, John W., 63 Moull St., Newark, Ohio
Tinsley, Stanley G., British Titan Products Co., Ltd., Billingham, Durham, England

Titanium Alloy Mfg. Co. (Librarian), Drawer D, Niagara Falls, N. Y.
Titus, H. B., North American Refractories Co., 50 Church St., New York 7, N. Y.
Tobitt, F. A., American Rolling Mill Co., Middletown, Ohio
Todd, Edwin R., 2143 Norton Rd., Charlotte, N. C.
Todd, Henry, Biggar, Saskatchewan, Canada
Tompkins, J. F., 5622 Chartres St., Houston 4, Texas
Tool, Arthur Q., National Bureau of Standards, Washington, D. C.
Tooley, F. V., Owens-Corning Fiberglas Corp., Newark, Ohio
Topping, John, 434 Carnegie Bldg., Pittsburgh, Pa.
Torno, Ralph F., 369 Front St., 1, Berea, Ohio
Torok, Julius J., 134 E. Fourth St., Corning, N. Y.
Toulouse, Julian H., 1817 Potomac Dr., Toledo 7, Ohio
Townsend, Leslie, 239 East 7th St., Lansdale, Pa.
†Trabert, Loren A., 125 Nichols St., Fostoria, Ohio
†Tredennick, William T., 5428 Woodbine Ave., Philadelphia, Pa.
*†Treischel, C. C., R. T. Vanderbilt Co., 230 Park Ave., New York 17, N. Y.
Trenton Potteries Co., Plant 5, Box 141, Trenton 1, N. J.
Trevathan, P. Edward, Engr. Exp. Sta., Ohio State Univ., Columbus 10, Ohio
Trevor, John F., Moira Rd., Woodville, near Burton-on-Trent, England
Trost, Conrad, Mellon Inst., Pittsburgh 13, Pa.
*†Trostel, L. J., General Refractories Co., Box 1673, Baltimore 3, Md.
Trott, R. P., General Abrasive Co., Inc., Niagara Falls, N. Y.
Trowbridge, P. S., Hydraulic Press Brick Co., 1337 S. Kingshighway, St. Louis 10, Mo.
Troy, Walter J., 888 Chili Ave., Rochester, N. Y.
Truby, Harry A., 604 Ridge Ave., New Kensington, Pa.
Truesdell, Glenn C., Leland, Iowa
Tucker, Bradford S., E. J. Lavino and Co., 1528 Walnut St., Philadelphia, Pa.
Tucker, Edward F., Stebbins Engr. & Mfg. Co., Watertown, N. Y.
†Tucker, Harvey C., Allied Engr. Co., 4150 East 56th St., Cleveland 5, Ohio
Tulk, A. E., Sterling Grinding Wheel Co., Tiffin, Ohio
Turbett, Forrest L., Research Lab., Eagle Picher Lead Co., Joplin, Mo.
*Turk, Karl, Pemco Corp., 5601 Eastern Ave., Baltimore 13, Md.
*†Turk, Richard H., Pemco Corp., 5601 Eastern Ave., Baltimore 13, Md.
Turnbull, Edward D., 500 Penn Ave., Scranton 3, Pa.
Turnbull, John E., Apt. 5, 580 Blaine Ave., Akron, Ohio
Turnbull, Lt. Robert C. (Student), 22 Third St., Canisteo, N. Y.
Turner, A. A., 153 Lake Ave., Metuchen, N. J.
Turner, Cecil H., 811 Red Oak St., Charleston, W. Va.
Turner, Donald, Messrs. Lodge Plugs, Ltd., Rugby, England
Turner, Pickett, Jr. (Student), 706 Fifth Ave., Greensboro, N. C.
Turner, W. A., McLain Fire Brick Co., 1239 Gulf Bldg., Pittsburgh 19, Pa.
Turner, W. E. S. (Honorary), "Elmfield," Northumberland Rd., Sheffield 10, England
Tuttle, Milton (Student), Almond, N. Y.
*†Twells, Robert, Electric Auto-Lite Co., Spark Plug Div., Fostoria, Ohio
Twining, F. E., Twining Labs., Box 1472, Fresno 16, Calif.
Twyfords, Ltd., Cliffe Vale Potteries, Stoke-on-Trent, England
Tygart Valley Glass Co. (O. C. Noble), Washington, Pa.
Tyler, W. S., Co. (C. E. Jenks), 3615 Superior Ave., N. E., Cleveland 14, Ohio
Tyrrell, Miles E., 935 Main St., Wayne, Neb.

Ueltz, Herbert G. (Student), Ceramics Dept., Rutgers Univ., New Brunswick, N. J.
Uhrmann, Carl J., Box 13, Bellaire, Ohio
Ulmer, Carl D., Koppers Co., Research Dept., 945 Koppers Bldg., Pittsburgh, Pa.
Ulrich, Robert J., American Radiator & Standard Sanitary Corp., Litchfield Plant, Litchfield, Ill.
Underwood, R. R., Knox Glass Associates, Inc., Knox, Pa.
Union Electrical Porcelain Works, Inc. (F. W. Van Orden), Box 762, Trenton 5, N. J.
United Clay Mines Corp. (K. E. Ward), Oakland and Prospect Sts., Trenton 6, N. J.
United Glass Bottle Mfgrs., Ltd. (T. C. Moorshead), 8, Leicester St., London, W. C. 2, England
United States Glass Co. (C. W. Carlson), Tiffin, Ohio
United States Gypsum Co. (J. S. Offutt), 300 W. Adams St., Chicago 6, Ill.
Universal Clay Products Co. (C. A. Bloor), Sandusky, Ohio
Universal Dental Co. (Joseph Kohn), 48th and Brown Sts., Philadelphia, Pa.
Universal Potteries, Inc. (G. D. Agnew), Cambridge, Ohio
Universal Sanitary Mfg. Co. (W. Keith McAfee), New Castle, Pa.
Upton, Lee O., 58 Gorsline St., Rochester 13, N. Y.
Utter, Betty Anne (Student), 2778 Ridgeway Ave., Rochester 13, N. Y.
Utter, Joseph L. (Student), 52 Massachusetts Ave., Cambridge, Mass.

*Vail, James G., 502 W. Front St., Media, Pa.
Valentine, M. D., & Brother Co. (W. H. Peterson), Woodbridge, N. J.
Valentine, Peter C., 620 Market St., San Francisco 4, Calif.
†Vance, Edward D., Bay State Abrasive Products of Canada, Ltd., Brantford, Ontario, Canada
Van Cleave, A. A., 650 S. Highland Ave., Los Angeles 36, Calif.
Vanderbilt, R. T., Co. (Ira E. Sproat), 230 Park Ave., New York 17, N. Y.
Vanderpool, James W., 21 Spruce St., Dedham, Mass.
Vandolah, Harry J., 1015 Division St., Oak Park, Ill.
Van Gelderen, F. M., Enschede, Holland
Van Houten, Robert M., Kokomo Sanitary Pottery Corp., Kokomo, Ind.
Vanick, James S., International Nickel Co., Inc., 67 Wall St., New York 5, N. Y.
Van Nieuwenburg, C. J., Rotterdamsceweg, Delft, Holland
Van Orden, F. W., Union Electrical Porcelain Works, Inc., Box 762, Trenton 5, N. J.
*Van Schoick, Emily C., 60 E. Norwich Ave., Columbus 1, Ohio
Van Vlack, L. H., 7808 South Shore Dr., Chicago 49, Ill.
†Vaughan, T. Carter, 2736 Powhatan Parkway, Toledo, Ohio
*†Vaughan, W. Harry, 2420 Alston Dr., S. E., Atlanta, Ga.
Veale, Jack H., General Refractories Co., Baltimore, Md.
Venable, Charles R. (Student), 624 Clyde St., Pittsburgh 13, Pa.
Vereeniging Brick & Tile Co., Ltd. (L. Wishart), Box 49, Vereeniging, Transvaal, South Africa
Vesuvius Crucible Co. (Francis L. Arensberg), Box 8275, Swissvale, Pittsburgh 18, Pa.
Vickers, Arthur E. J., Hazeldene, Junction Rd., Norton-on-Tees, Durham, England
Victor Insulators, Inc. (H. Failmezger), Victor, N. Y.
Vidal, Hector G., Box 383, Fajardo, Puerto Rico
†Vincent, George L., 159 Oaklyn Terrace, Trenton, N. J.
Vincent, G. P., Mathieson Alkali Works, Inc., 60 East 42nd St., New York 17, N. Y.
Vitrefrax Corp. (R. W. Ellison), 5050 Pacific Blvd., Los Angeles 11, Calif.
Vitreous Steel Products Co. (Edgar H. Weil), Newburg Sta., Cleveland 5, Ohio
Vitro Mfg. Co. (E. M. Fleck), Corliss Sta., Pittsburgh, Pa.
Vodicka, Albert L., Aetna Porcelain Enameling Co., 4701 Augusta St., Chicago 51, Ill.
Vogt, Harold G., Main Plant Lab., Corning Glass Works, Corning, N. Y.

Vollmer, August, Jr., St. Louis Pottery Co., 5240–46 Northrup Ave., St. Louis, Mo.
Vollrath Co. (Jean C. Vollrath), 18th and Michigan Aves., Sheboygan, Wis.
Vollrath, A. J., 2123 North 6th St., Sheboygan, Wis.
Vollrath, Jean C., Vollrath Co., 18th and Michigan Aves., Sheboygan, Wis.
Vontury, Frances J., Lehigh Ave., Perth Amboy, N. J.
Voorhies, John H., 4770 Kester Ave., Sherman Oaks, Calif.
Voss, Walter C., Rm. 5–229, Massachusetts Inst. of Tech., Cambridge, Mass.

Waggoner, Jack H., 240 Quentin Rd., Newark, Ohio
Wagner, Harold F., Roseland, Neb.
Wagner, Rio B., 4540 E. Main St., Columbus, Ohio
Wainer, Eugene, 2654 Whirlpool St., Niagara Falls, N. Y.
Waite, Virgil H., 433 Beech St., Berea, Ohio
Walden, Albert S., National Carbon Co., Cleveland, Ohio
†Waldschmidt, Milton H., 873 Ebner St., Columbus, Ohio
Walker, A. M., Australian Tesselated Tile Co., Mitcham, Victoria, Australia
Walker, F. L. (Student), 118 Champlain Ave., Decatur, Ga.
Walker, Herbert M., Walker China Co., Bedford, Ohio
Walker, Keith F., 711 E. Tyler St., Athens, Texas
Walker, Lt. (jg) Leander H., Patuxent River, Md.
Walker, Prescott H., Carborundum Co., Niagara Falls, N. Y.
Wallace China Co., Ltd. (Wallace B. Wood), Box 47, Huntington Park, Calif.
Wallace, Curtis C., Electric Storage Battery Co., Allegheny Ave. & 19th Sts., Philadelphia, Pa.
Wallace, William W., 509 Norwood Ave., New Castle, Pa.
Walsh, Donald E., 2507 St. Clair Ave., East Liverpool, Ohio
Walsh, F. A., Gladding, McBean & Co., Lincoln, Placer County, Calif.
Walsh Walsh, John, Ltd. (W. G. Riley), Soho & Vesta Glassworks, Birmingham 18, England
Walsh, N. S. C., 4070 N. First St., St. Louis 7, Mo.
Walsh Refractories Corp. (J. L. Crawford), 4070 North First Street, St. Louis 7, Mo.
Waltham Grinding Wheel Co. (Robert L. Lyons), Waltham, Mass.
*†Walton, S. F., Exolon Co., Tonawanda, N. Y.
Walworth, Chester A., Libbey-Owens-Ford Glass Co., Charleston 30, W. Va.
Wampler, Roy W., Libbey-Owens-Ford Glass Co., Technical Bldg., 1701 E. Broadway, Toledo, Ohio
Wanner, Edwin F., 8611 Lynnbrook Dr., Bethesda 14, Md.
Ward, Charles J., 22 Bracondale Hill Rd., Toronto 10, Ontario, Canada
Ward, George W., 7555 South Shore Dr., Chicago 49, Ill.
Ward, K. E., United Clay Mines Corp., Oakland and Prospect Sts., Trenton 6, N. J.
Ward, S. Paul, 605 Mission St., South Pasadena, Calif.
Warde, John M., Vereeniging Brick & Tile Co., Vereeniging, Transvaal, South Africa
Wardley, Thomas, Westpoint Rockware Ave., Greenford, Middlesex, England
Warren, Bertram E., Massachusetts Inst. of Tech., Cambridge, Mass.
Washburn, C. Eldyn, 864 Hickman Rd., Augusta, Ga.
WashingtonBrickCo.(ThomasSomervilleIII),Muirkirk,Md.
Washington Porcelain Co. (C. H. Ackerson), Willow St., Washington, N. J.
Watkin, Robert W., 2505 St. Clair Ave., East Liverpool, Ohio
Watkins, George B., Libbey-Owens-Ford Glass Co., 1701 E. Broadway, Toledo, Ohio
Watkins, Joel H., Charlotte C. H., Va.
Watkins, Ray T., U. S. Tariff Commission, Ceramic Div., Washington, D. C.
Watkins, W. J., Kentucky Clay Mining Co., Mayfield, Ky.
Watson, William, Box 49, Vereeniging, Transvaal, South Africa
Watt Pottery Co. (Loren Watt), Crooksville, Ohio
Watt, Loren, Watt Pottery Co., Crooksville, Ohio
Watts, Lt. Arthur P., Ruxton, Baltimore 4, Md.
*†Watts, Arthur S., Lord Hall, Ohio State Univ., Columbus 10, Ohio
Watts, E. F., Binks Mfg. Co., 3114 Carroll Ave., Chicago, Ill.
Watts, Gerald F., A. E. Hull Pottery Co., Crooksville, Ohio
Watts, H. L., Dept. of Mines, Industrial Minerals Div., Lydia St., Ottawa, Ontario, Canada
Wayne Labs. (John J. Shank), 17 E. Main St., Waynesboro, Pa.
Weathers, W. M., International Smelting & Refining Co., 577 Malvern Rd., Akron 3, Ohio
Weaver, B. Douglas, Box 565, Ancor Corp., St. George, S. C.
Weaver, H. F., Peerless Pottery, Inc., 917 N. St. Joseph Ave., Evansville, Ind.
Weaver, R. A., Ferro Enamel Corp., 4150 East 56th St., Cleveland 5, Ohio
Webb, Herbert, Coalbournhill Glass Works, Stourbridge, Worcestershire, England
Webber, Major John J., New Orleans, La.
Weber, Arthur W., Corning Glass Works, Charleroi Div., Charleroi, Pa.
Weber, August, Jr., 1155 Stratford Rd., Schenectady 8, N. Y.
†Webster, Charles E., 311 E. Beaver St., Zelienople, Pa.
Webster, Hugh B., Harshaw Chemical Co., 12 South 12th St., Philadelphia 7, Pa.
Webster, Paul A., Moravia Rd., Avon, Conn.
Wedemeyer, N. G., Röhm & Haas Co., 222 W. Washington Sq., Philadelphia, Pa.
Wehtje, Ernst, Postbox 129, Malmö, Sweden
Wehtje, Karl F., A/B Rörstrands Porslinsfabriker, Lidkopings Porslinsfabrik, Lidköping, Sweden
Weidman, V. Wesley, 8091 W. Rivershore Dr., Niagara Falls, N. Y.
Weigel, Robert C., 121 E. Pleasant St., Mexico, Mo.
Weil, Edgar H., Vitreous Steel Products Co., Newburg Sta., Cleveland 5, Ohio
Weinfurtner, E. M., North American Refractories Co., National City Bank Bldg., Cleveland, Ohio
Weinheimer, Peter F., Perry Furnace Co., Erie, Pa.
Weinstein, Alex, Ednal Co., 95 Madison Ave., New York 16, N. Y.
†Weis, J. H., Solvay Process Co., Kings Mountain, N. C.
Weiske, Ino (Student), Box 353, Mission, Texas
Weiss, E. Joseph (Student), 73 N. Cassingham Rd., Columbus, Ohio
Welch, Arnold P., 1032 Colony St., Saskatoon, Saskatchewan, Canada
Welch, Richard L., Georgetown Clay Products, Ltd., Georgetown, Ontario, Canada
Weldon, Walter A., 621 Edgewood St., Baltimore 29, Md.
Wellech, Edmund H., 75 W. Fifth St., Corning, N. Y.
Weller, Harvey C., Surface Combustion Corp., 2375 Dorr St., Toledo, Ohio
Welliver, William E., Georgia Kaolin Co., 1185 Mary St., Elizabeth, N. J.
*Wells, A. A., Homer Laughlin China Co., Newell, W. Va.
Wells, Joseph, Homer Laughlin China Co., Newell, W. Va.
Wells, Lloyd L., Jr., 7853 S. Coles Ave., Chicago 49, Ill.
Welshans, Lewis T., 404 Mentor Ave., Painesville, Ohio
Welter, J. T., R. D. 3, Tiffin, Ohio
Wenczel, Stephen, New Jersey Porcelain Co., Box 908, Trenton 5, N. J.
Wendt, Nelson E., American Potash & Chemical Corp., 122 East 42nd St., New York 17, N. Y.
Wenger, A. H. C., Messrs. Wengers, Ltd., Etruria, Stoke-on-Trent, England
Wenning, W. F., Ceramic Color & Chemical Mfg. Co., Box 297, New Brighton, Pa.
Werner, Alan J., 159 E. Fourth St., Corning, N. Y.
West, Carl, Jr., 429 Second Ave., S. W., Rochester, Minn.
West, Frank, Haslemere Greenlane, Buxton, Derbyshire, England
West, Howard F., 922 Washington St., Lockport, Ill.
Westall, Charles C., Burns Apts., Kittanning, Pa.
Western Brick Co. (I. R. Cline), Danville, Ill.

Western Electric Co. (L. I. Shaw, 7420), Hawthorne Sta., Chicago 23, Ill.
Western Feldspar Milling Co. (J. W. Magnuson), 1333 W. Maple St., Denver, Colo.
Westinghouse Electric & Mfg. Co. (E. H. Fischer), Derry, Pa.
Westinghouse Electric & Mfg. Co., Glass Plant (LeGrand Jarrett), Fairmont, W. Va.
*Westman, A. E. R., Ontario Research Foundation, 43 Queen's Park, Toronto 5, Ontario, Canada
Westmont, O. B., Johns-Manville Products Corp., Lompoc, Calif.
†Weston, Ralph H., Arketex Ceramic Corp., Brazil, Ind.
West Virginia Brick Co. (Claude F. Wiseman), Charleston, W. Va.
Weyburne, F., Marshall-Eclipse Div. of Bendix Aviation Corp., Box 538, Troy, N. Y.
Weyl, Woldemar, Glass Science, Inc., Pennsylvania State College, State College, Pa.
Wheaton, Frank H., Millville, N. J.
Wheaton, Frank H., Jr., 1118 N. High St., Millville, N. J.
Wheaton, L. Don (Student), T. C. Wheaton Co., Millville, N. J.
Wheaton, T. C., Co. (Frank H. Wheaton, Jr.), 1118 N. High St., Millville, N. J.
*Wheeler, Herbert A. (Charter Life), 900 Security Bldg., St. Louis, Mo.
Wheeler, Thorne L., Arthur D. Little, Inc., 30 Memorial Dr., Cambridge 42, Mass.
Wheeling Steel Corp. (Warren F. Copp), Yorkville, Ohio
Whelan, Paul T., 1388 E. Delavan Ave., Buffalo 15, N. Y.
Whipple, A. D., 5241 N. Kimball Ave., Chicago 25, Ill.
†Whitaker, Fred A., General Ceramics Co., Keasbey, N. J.
Whitaker, H., Rustless Iron Co., Ltd., Trico Works, Keighley, England
†Whitaker, L. R., Carolina Ceramics, Inc., Box 1257, Columbia, S. C.
White, Eugene, 6328 Clara St., Bell, Calif.
*White, Harold E., R. D. 6, Butler, Pa.
White, Jonathan S., 1302 Singer Place, Wilkinsburg, Pittsburgh 21, Pa.
White, R. H., Alden Park Manor, Germantown, Philadelphia, Pa.
Whitelegge, J. G., 4 Pennell St., Clayton, Manchester 11, England
Whiteley, Joseph O., Dentists' Supply Co., York, Pa.
Whitener, William J. (Student), R. D. 1, Gastonia, N. C.
Whitesell, Buhel E., Saltsburg, Pa.
Whitesell, Lysle E., Wellsville, Mo.
Whitesell, Robert J., 8313 Roberts Rd., Elkins Park 17, Pa.
*Whitford, William G., Graduate Education Bldg., Box 30, Univ. of Chicago, Chicago 37, Ill.
Whitmer, J. D., Sparta Ceramic Co., East Sparta, Ohio
Whitney, Eugene H., Box 630, Pittsburg, Calif.
Whittaker, Clyde M., 203 Englewood Ave., New Castle, Pa.
†Whittaker, Harry, Research Labs., Crane Co., 4100 S. Kedzie Ave., Chicago 5, Ill.
*†Whittemore, J. W., Virginia Polytechnic Inst., Blacksburg, Va.
Whittemore, O. J., Box 603, Fort Dodge, Iowa
Whittemore, O. J., Jr., Room 4-049, Massachusetts Inst. of Tech., Cambridge 39, Mass.
Whittington, Lloyd R., 513 E. Robinson Ave., Barberton, Ohio
Wiedemann, H. E., Chemical Bldg., St. Louis 1, Mo.
Wiker, Richard M., 315 W. Pulteney St., Corning, N. Y.
Wilcox, Herman G., 742 Loretta St., Pittsburgh 17, Pa.
Wildenhain, Marguerite, Pottery Pond Farm, Guerneville, Calif.
Wilhelms, Kenneth M. (Student), 509 West 11th St., Rolla, Mo.
Willems, H. W. V., 215 Cedar St., Corning, N. Y.
Willmore, Tracy A., Jr., 507 W. South St., Clinton, Ill.
*Wilkes, Gordon B., Massachusetts Inst. of Tech., Cambridge 39, Mass.
Wilkins, Marion C. (Student), 330 Porter Bldg., San Jose, Calif.
†Williams, Alan B., 2725 Walton Way, Augusta, Ga.
Williams, Arthur E., 3871 Rodman St., N. W., Apt. F 60, Washington 16, D. C.
Williams, Charles K., 351 Ogden St., East Liverpool, Ohio
Williams, Clyde E., 505 King Ave., Columbus, Ohio
Williams, Francis J., National Lead Co., Research Labs., 105 York St., Brooklyn, N. Y.
Williams, George F., 130 Platt St., Painted Post, N. Y.
Williams, Harry M., 718 President Ave., Trenton 9, N. J.
Williams, John A., Box 250, Trenton 2, N. J.
Williams, Meryl D., 306½ W. Ohio St., Midland, Texas
Williams, Robert A., Franklin Tile Co., Lansdale, Pa.
Williams, Walter E., 1519 Myrtle Ave., Zanesville, Ohio
Willmore, Tracy A., Jr., 507 W. South St., Clinton, Ill.
Willson Products, Inc. (Thomas A. Willson), Box 622, Reading, Pa.
Willson, Herbert S., 256 Bridge St., Corning, N. Y.
Willson, Thomas A., Willson Products, Inc., Box 622, Reading, Pa.
Wilson, Charles L., 309 N. Meridian St., Brazil, Ind.
Wilson, Earl O., 457 West 7th St., Claremont, Calif.
Wilson, George, 131 Edison Ave., New Castle, Pa.
*†Wilson, Hewitt, Electrotechnical Lab., Bureau of Mines, Norris, Tenn.
Wilson, Maurice S. (Student), 3 Orchard St., Shelton, Conn.
Wilson, Richmond W., 142 Pine St., Corning, N. Y.
Winburn, H. L., Box 1735, Little Rock, Ark.
Winburn, Sinclair W., 1709 E. Ninth St., Little Rock, Ark.
Windisch, Robert P., Roseville Pottery, Inc., Zanesville, Ohio
Winemiller, William F., 148 E. Dunedin Rd., Columbus, Ohio
Winship, William W., Thermal Syndicate, Ltd., 12 East 46th St., New York 17, N. Y.
Winstone's Roofing Tile Works, Ltd. (C. G. Hillier), Taumarunui, North Island, New Zealand
Winter, Aniuta, "École Libre des Hautes Etudes," 66 5th Ave., New York 11, N. Y.
Winters, F. T., Pacific Coast Borax Co., 51 Madison Ave., New York 10, N. Y.
Wisconsin Porcelain Co. (L. A. Stohl), Sun Prairie, Wis.
Wise, L. G., E. I. du Pont de Nemours & Co., Inc., Chemical Dept., Exptl. Sta., Wilmington, Del.
Wiseman, Claude F., West Virginia Brick Co., Charleston, W. Va.
Wishart, L., Vereeniging Brick & Tile Co., Ltd., Box 49, Vereeniging, Transvaal, South Africa
Wishoski, I. Stanley, Editor, *Industrial Heating*, 1400 Union Trust Bldg., Pittsburgh 19, Pa.
Wiss, J. E., 1339 Lincoln Rd., Columbus, Ohio
Witkowski, Stanley, 60 Harding Ave., Oaklyn, N. J.
Witschey, R. A., A. P. Green Fire Brick Co., 122 S. Michigan Ave., Chicago 3, Ill.
Witzemann, A. William, 265 E. Tulane Rd., Columbus 2, Ohio
Woldman, N. E., Eclipse Pioneer Div., Bendix Aviation Corp., Bldg. 1, Teterboro, N. J.
*†Wolfram, H. G., Pemco Corp., Baltimore 24, Md.
Wolfskill, J. M., Bliley Electric Co., Union Sta. Bldg., Erie, Pa.
Womeldorph, Raymond C. (Student), Lovettsville, Va.
Wong, Po Kay (Student), 1055 Washington St., San Francisco 8, Calif.
Wood, Joseph L., Mathieson Alkali Works, Inc., Niagara Falls, N. Y.
Wood, Wallace B., Wallace China Co., Ltd., Box 47, Huntington Park, Calif.
Woodall, Edward L., Jr. (Student), 408 S. Fourth St., Smithfield, N. C.
Woodruff, Ernest W., 219 E. North Water St., Chicago 11, Ill.
Woods, William J., Box 627, Lewistown, Pa.
Woodville Lime Products Co. (J. Robert Cowell, Jr.), 2140 Jefferson Ave., Toledo, Ohio
Woody, Fred C., 13810 Cranwood Park Blvd., Cleveland 5, Ohio
Wooley, Seward E. (Student), Engr. Expt. Sta., Ohio State Univ., Columbus 10, Ohio

Worcester Royal Porcelain Co., Ltd. (Joseph F. Gimson), Royal Porcelain Works, Worcestershire, England
*†Worcester, W. G., Dept. of Ceramics, Univ. of Saskatchewan, Saskatoon, Saskatchewan, Canada
Work, Harold K., Jones & Laughlin Research Lab., 40 Longworth St., Pittsburgh, Pa.
Work, Lincoln T., Metal & Thermit Corp., Box 255, Rahway, N. J.
Wortley, G. W., R. & A. Main, Ltd., Gothic Works, Falkirk, Scotland
Wright, Ann T., 121 Clifton Ave., Minneapolis, Minn.
Wright, Daniel K., Incandescent Lamp Dept., General Electric Co., Nela Park, Cleveland 12, Ohio
†Wright, Edward P., Box 387, East Liverpool, Ohio
Wright, George C., 95 Union Ave., Pittsburgh 5, Pa.
Wright, J. E., Messrs. A. G. Hackney & Co., Ltd., Fairfield Pottery, Hanley, Stoke-on-Trent, England
Wright, J. W., 1129 Warren St., Alton, Ill.
Wulf, Charles A., American Valve & Enameling Corp., Box 114, Indianapolis 6, Ind.
Wurtsbaugh, C. G., Pacific Clay Products, 306 West Ave. 26, Los Angeles 31, Calif.
Wyatt, De Witt H., 123 Acton Rd., Columbus, Ohio
Wyckoff, Lewis B., Electro Metallurgical Co., Niagara Falls, N. Y.
Wygant, Pvt. James F., Univ. of Alabama, University, Alabama
Wysong, Charles F., 2221 Willow Ave., Atlanta, Ga.
Wysor, D. C., General Chemical Co., 40 Rector St., New York 6, N. Y.

Yanovsky, Alexander, 16 Izola Ave., Fords, N. J.
Yarte, Andrew A., Apartado 486, Monterrey, N. L., Mexico
Yates, Paul L., Crane Enamelware Co., 33rd & Alton Park Blvd., Chattanooga, Tenn.
Yavorsky, Paul J., 3028 Porter St., N. W., Washington 8, D. C.
Young, Robert J., Chicago Hardware Foundry Co., North Chicago, Ill.
Young, Ens. Robert W. (Student), 3 Pulsiter Ave., Yonkers, N. Y.
Young, Stanley H., 1419 Cleveland Ave., N. W., Canton, Ohio
†Young, Willard G., W. A. Case & Son Mfg. Co., 33 Main St., Buffalo, N. Y.
Young, William O., 1796 Tonawanda Ave., Akron 5, Ohio
Yount, Richard V., CWS Development Labs., Massachusetts Inst. of Tech., Cambridge, Mass.

Zabawsky, Zeno, 1711 18th St., N. W., Washington 9, D. C.
Zahn, William A., 370 Central Ave., Orange, N. J.
Zahniser, George B., 109 Englewood Ave., New Castle, Pa.
Zapfe, Richard C., 162 Pennfield St., Pomona, Calif.
Zapffe, Carl A., Rustless Iron & Steel Corp., 3400 E. Chase St., Baltimore 13, Md.
Zapun, C. G., Zapun Ceramics, 43–00 36th St., Long Island City, N. Y.
Zarbo, George, Fenimore St., near Second, Vineland, N. J.
Zeamans, Miss Naomi (Student), Box 665, Alfred, N. Y.
Zehm, Robert C., Joseph Dixon Crucible Co., Jersey City, N. J.
Zeiller, Irwin F., B. F. Drakenfeld & Co., Inc., 45–47 Park Place, New York 7, N. Y.
Zeiller, Oscar F., 42–38 204th St., Bayside, Long Island City, N. Y.
Zerfoss, Samuel, 226 Mineral Industries Bldg., State College, Pa.
Zimmer, Daniel B., 1381 Sedgwick Ave., New York, N. Y.
†Zimmer, David C., Patterson Foundry & Machine Co., East Liverpool, Ohio
Zimmer, Major Warren A., San Francisco, Calif.
Zinszer, William K., 194 Oak Court, Palo Alto, Calif.
†Zvanut, Frank J., Ferro Enamel Corp., 4150 East 56th St., Cleveland, Ohio
Zweig, Benson (Student), Apt. 511, 4607 Connecticut Ave., N. W., Washington, D. C.
†Zwermann, Lt. Col. Carl H., 806 W. Main St., Robinson, Ill.

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SYMPOSIUM ON "SIGNIFICANCE OF TESTS ON REFRACTORIES"

The following three papers were part of the Symposium which was presented at the Forty-Sixth Annual Meeting of The American Ceramic Society, Inc., Pittsburgh, Pa., April 4, 1944. Clyde L. Thompson, chairman of the Refractories Division, acted as chairman of the Symposium. E. E. Callinan was chairman of the Program Committee.

See Bull. Amer. Ceram. Soc., **23** [9] *310–20 (1944) for papers by S. M. Phelps, F. A. Harvey, and W. S. Debenham.*

SIGNIFICANCE OF THE PYROMETRIC CONE EQUIVALENT TEST OF REFRACTORIES AND REFRACTORY RAW MATERIALS*

By Robert B. Sosman†

Abstract

The pyrometric cone equivalent test is not a temperature measurement. It is a test of similitude in thermal behavior between a standardized and an unknown refractory. By proper care of conditions of heating it can be made reproducible within one cone number for clays and fire-clay refractories. It gives quick and easily acquired indications concerning flow of the refractory under light load at high temperature, but should be supplemented by the regular hot-load and other tests.

I. Definition

The test herein referred to is the American Society for Testing Materials Standard Method of Test for Pyrometric Cone Equivalent (P.C.E.) of Refractory Materials, No. C24–42, with tentative revision of March, 1943.[1]

The standard pyrometric cones listed for use in the test are Nos. 15 to 42, inclusive. Four of the cones in this series, viz., Nos. 21, 22, 24, and 25, which formed a part of the original Seger series, are now omitted because the intervals between cones were found to be too small. The cones following No. 20 are therefore Nos. 23 and 26, after which the series runs integrally to No. 32. A wider interval in indicating temperature between Nos. 32 and 33 has led to the introduction of a No. $32\frac{1}{2}$ between these two. The series is then completed in Nos. 34 to 42.

The cones used for this test are smaller than those regularly used in the control of kiln firing, being only $1\frac{1}{8}$ inches high in place of $2\frac{1}{4}$ inches.

The standard cones actually being manufactured in the small size for the purpose of testing refractories include only Nos. 23 to 42 of the previously described series.

II. Composition of Test Cones

The series of refractory test cones from 28 to 42 is based nominally upon mixtures of kaolinite ($Al_2O_3 \cdot 2SiO_2 \cdot 2H_2O$), quartz ($SiO_2$), and alumina ($Al_2O_3$). They therefore make a series in the binary system Al_2O_3–SiO_2. The equilibrium diagram of this system as worked out by Bowen and Greig[2] and recently corrected[3] is shown in Fig. 1. Against this background, in Fig. 2 are plotted the compositions of the refractory cone series Nos. 28 to 42, together with the temperatures of indication assigned to them by the work of Fairchild and Peters at the National Bureau of Standards.[4]

Cones 4 to 27 are more complex in composition, being made up from mixtures of quartz, kaolinite, calcium carbonate, and potash feldspar ($K_2O \cdot Al_2O_3 \cdot 6SiO_2$). In terms of oxides, therefore, these cones lie in the four-component

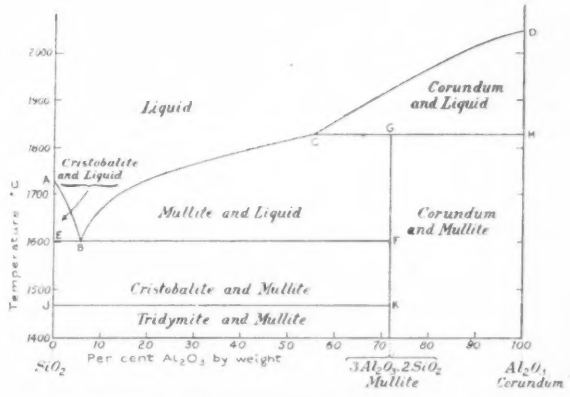

FIG. 1.—Composition-temperature diagram of the system Al_2O_3–SiO_2, according to Bowen and Greig, with correction by Schairer (temperature of eutectic *EF*). Temperature is on the International Scale.

system SiO_2–Al_2O_3–CaO–K_2O. Their relation to each other and to the alumina-silica series 28 to 42 would be difficult to represent graphically, but if, for purposes of representation only, we consider the slow-melting and viscous feldspar to be a kind of diluent of the other constituents, we may represent their relative proportions on the plane of

* Received August 30, 1944.

† Chairman, Section (C) on Temperature, Subcommittee III on Tests, Committee C–8 on Refractories, American Society for Testing Materials.

[1] Manual of A.S.T.M. Standards on Refractory Materials, June, 1943, pp. 58–61; *Ceram. Abs.*, **22** [11] 194 (1943).

[2] N. L. Bowen and J. W. Greig, "System Al_2O_3–SiO_2," *Jour. Amer. Ceram. Soc.*, **7** [4] 238–54; [5] 410 (1924).

[3] J. F. Schairer, "System CaO–FeO–Al_2O_3–SiO_2: I, Results of Quenching Experiments on Five Joins," *ibid.*, **25** [10] 241–74 (June 1, 1942); p. 243, Fig. 2.

[4] C. O. Fairchild and M. F. Peters, "Characteristics of Pyrometric Cones," *ibid.*, **9** [11] 701–43 (1926).

the ternary system CaO–Al_2O_3–SiO_2. This is done in Fig. 3. One reason for the elimination of cones 21, 22, 24, and 25 is immediately obvious; it is arithmetical as much as it is chemical and resulted from a bad choice of "preferred numbers" in the original series of formulas.

III. Manner of Indication

The cone indicates by bending over in the direction in which it has been slanted (one face at 8 degrees from the vertical) when set in the plaque, and it is "down" at the time and temperature when its tip just touches the plaque. The P.C.E. of the unknown material being tested is the number of the cone which was most nearly down when the unknown was down.

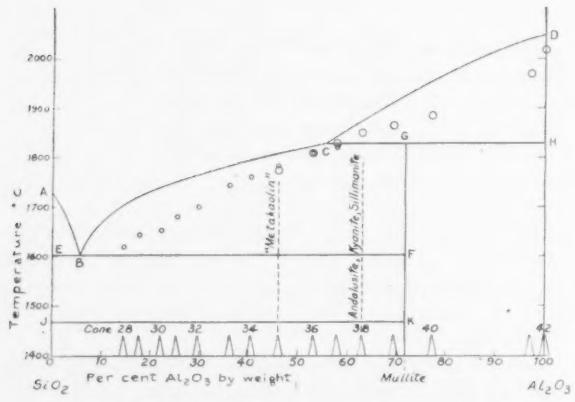

FIG. 2.—Composition-temperature diagram of the system Al_2O_3–SiO_2 (from Fig. 1) showing nominal compositions of pyrometric cones Nos. 28 to 42 and cone end points as determined by Fairchild and Peters. *Small circles:* heating rate 100°C. per hour in air. *Large circles:* heating rate 600°C. per hour in graphite-helix vacuum furnace. Metakaolin is the product formed by dehydration of kaolinite, $Al_2O_3 \cdot 2SiO_2 \cdot 2H_2O$. Cone $32\frac{1}{2}$ was not included in the series studied by Fairchild and Peters.

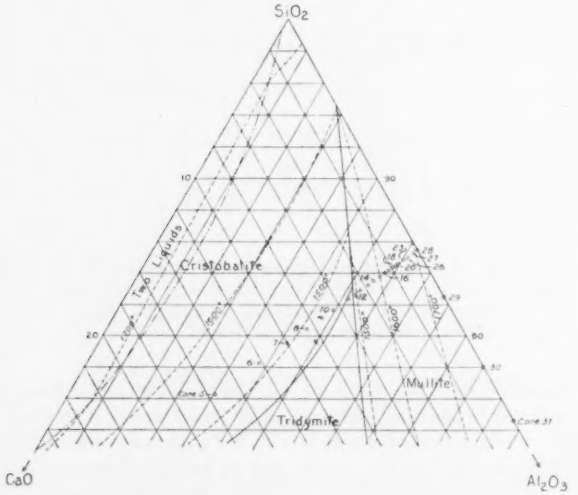

FIG. 3.—Composition of cones 5 to 27 with orthoclase ($K_2O \cdot Al_2O_3 \cdot 6SiO_2$) eliminated from the formula. Plotted on phase equilibrium diagram of the system CaO–Al_2O_3–SiO_2, with temperature of liquidus surface shown in degrees centigrade and composition in weight per cent.

The cone bends because of the formation and slow flow of a liquid silicate which forms by reactions between the constituents of the cone. If the crystalline phases present were always in equilibrium, and if the flow of the siliceous liquid were purely viscous, the bending of a cone would be controlled primarily by the temperature of the lowest eutectic in the appropriate field of its phase equilibrium diagram.[5] It is, in fact, found that some cones can be brought down at a lower temperature than normal by holding them for a long time at a constant or very slowly rising temperature.

It is conceivable, however, that the flow under some circumstances, particularly when there is a large proportion of crystalline material and a small proportion of liquid, may be of plastic character; i.e., there is no flow whatever until the distorting force exceeds a certain critical value. Such a cone would not bend at all until the amount of liquid, or the fluidity of the liquid, had increased to a point where the force due to gravity exceeded the critical value

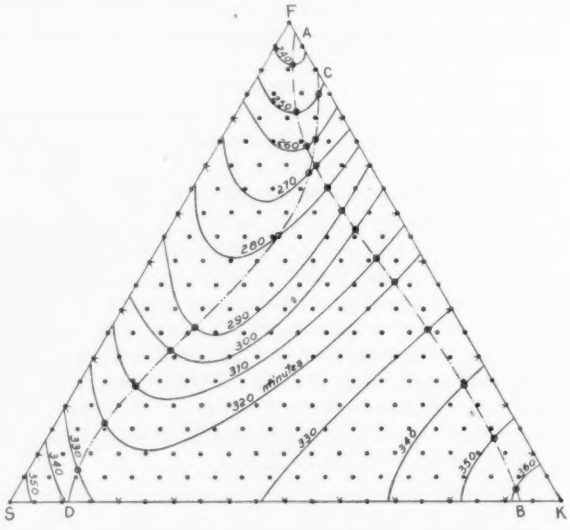

FIG. 4.—Imaginary composition-time diagram for the bending of all cones compounded from hypothetical substances $F + K + S$. Curves are isochrones connecting points of equal time of bending and outlining an isochronous surface.

necessary for the beginning of plastic flow. It follows that if plastic flow is indeed a factor, then a series of cones, all of which are controlled by the same eutectic, will not necessarily all come down at the same temperature even though held at a constant temperature, above the eutectic value, for an indefinite period.

From what has been said, it should be clear that time is an influential variable in the performance of a pyrometric cone, though not as important as temperature. The proportion of liquid in the silicate system, and especially the fluidity of the siliceous liquid, increases so rapidly with temperature that temperature is the fundamental controlling variable. Nevertheless, the time interval that elapses while a given temperature is being attained is an important

[5] R. B. Sosman, "Physical Chemistry of Seger Cones," *Trans. Amer. Ceram. Soc.*, **15**, 482–98 (1913).

factor, as evidenced by the necessity of prescribing the rate at which the cones shall be heated.

As the cones are always used in groups, and the comparison is between one cone and another in a series, the emphasis is on temperature *intervals* rather than on the exact temperature itself.

The logic of the P.C.E. test can be illustrated by an imaginary research for the purpose of developing a new series of test cones. Figure 4 represents the supposed results of observations on the time of bending of each of 231 cones, made up by mixing the three components *F*, *K*, and *S* in proportions differing by 5%. The materials are assumed to be such that the cones do actually bend through a time and temperature interval and do not slump suddenly at a sharp melting point, as a pure metal or salt would do. Composition is represented, as usual, by points in an equilateral triangle. Time (*not* temperature) is measured perpendicularly to the plane of the triangle. The entire lot of cones is supposed to be heated at a prescribed rate, e.g., 300°C. per hour or 5°C. per minute, in a furnace whose temperature at any moment is uniform throughout the region occupied by the cones. The time when the tip of each cone touches the plaque surface is recorded. A plot of these data gives a time surface, outlined in Fig. 4 by a set of isochrones or curves of equal time. (This figure has the approximate shape of an actual set of such determinations made on mixtures of feldspar, kaolin, and flint.[6])

We may now draw any kind of curve across the surface in such a way that it rises continuously from a region of early bending time to a region of late bending time, e.g., the curve *AB*. The compositions at which *AB* intersects the equally spaced isochrones are the compositions of a satisfactory series of pyrometric cones. An equally satisfactory set of cones can be derived from the curve *CD*, or in fact from any arbitrary curve that traverses the desired range of time and, consequently, of temperature. Suppose the cones are numbered in accordance with their bending time in minutes. Then series *AB* and series *CD*, if used at the prescribed rate, will yield identical P.C.E. values for any material which is tested with their aid.

Now suppose the prescribed rate of heating is halved. In general, the two cone series *AB* and *CD* will still give approximately the same cone number (P.C.E.) for an unknown material, but will not agree perfectly because their viscosity, internal reaction rate, and other variables are likely to be differently influenced by temperature. They can be made to agree exactly only if a new time-composition prism is determined by measurements made at the new heating rate, and a modified series of cone compositions is derived therefrom.

If any choice is to be made among the various curves that can be drawn across Fig. 4, that one should be selected which most nearly represents the composition of the materials that will usually be tested, because if cones and test material are alike in composition and constitution, the same cone number will be obtained, whatever the rate of heating may be.

This imaginary piece of research is, in a way, an epitome of what has actually occurred in the development of the cones as now manufactured. Adapting themselves to small variations in composition and fineness of grain of the available raw materials, the cones have gradually departed by small increments from Seger's original compositions, until some of them are probably far off the nominal formula. With the cones of lower number, these departures have also been influenced by the effort to avoid such undesirable effects as "freezing" and susceptibility to reducing atmosphere. The manufacturer is under no obligation to tell us their actual composition, because if the new cone, when heated at the prescribed rate, comes down at precisely the same moment as the original standard, and at the same time is not seriously influenced in its behavior by the heating rate, nothing more can fairly be asked of it.

IV. Nature of the P.C.E. Test

The foregoing discussion emphasizes an important point: the pyrometric cone, in spite of its name, is not fundamentally a pyrometric device. The P.C.E. test of a refractory is essentially a test of similitude in thermal behavior between a series of standardized refractory mixtures and the unknown material.

The discussion will also have brought out the point that the P.C.E. test, subject like all tests to occasional and unpredictable vagaries of the observer, will be most consistently reliable when used in testing materials having nearly the same composition and constitution as the cones themselves and will be least reliable when the materials are radically different from the cones in composition or in thermal behavior.

It follows that to report a P.C.E. test in terms of temperature, using the Fairchild-Peters or any other table of equivalents, is quite incorrect. The test is a comparison of thermal behavior in terms of standard cones, not a measurement of temperature, and should therefore be reported in cone numbers, not in degrees. This is not to disparage Fairchild and Peters' demonstration that the cones can be used successfully to measure the temperature of a uniformly heated enclosure, provided the specified heating rate is adhered to.

V. Precision of the P.C.E. Test

Pyrometric cone equivalent tests of a given refractory product or refractory raw material, made by two laboratories, with due attention to rate of heating, correct setting, avoidance of abnormal atmosphere, and provision for uniformity of temperature within the furnace, should not differ by more than one cone number.

It is possible to influence the indication of the cones by the method of heating. This is brought out particularly in reported differences between the indications of cones heated in gas-air-fired furnaces and in an electric-resistance furnace. In testing certain materials having a cone number below 30, it is possible to obtain a result one cone lower in the electric furnace and in the oxyacetylene furnace than in the gas-air furnace. Not all the determinations are consistent, however, as a few observers have reported identical results in the two or three types of furnace. A summary of comparative results obtained under the auspices of the American Refractories Institute Fellowship at the Mellon Institute showed that the results were less reproducible in electric and oxyacetylene than in gas-air furnaces. The whole subject of P.C.E. furnaces needs further study.

[6] M. Simonis, "Die Kegelschmelzpunkte von Gemischen aus Zettlitzer Erde, Quarz und Feldspat." *Sprechsaal*, **40**, 390–92, 403–406 (1907).

When it comes to comparisons within a single laboratory, the agreement is surprisingly close. As a general rule in physical testing, it is true that a skillful manipulator can obtain close agreement even with a very complex test. At the Kentucky Fire Brick Company, with whose past practice the author has been familiar, the ceramic engineer* informs us that he obtains check results on his clays to one quarter of a cone. In other words, if he has three clays which come down in succession between the end points of cones 32 and 32½, he can redetermine them with new cones and obtain the same order in the same cone interval. As the average temperature interval between cones in this part of the series is only 20°C. or 36°F., this is quite precise working. This order of precision cannot be expected in the testing of all refractory clays because the time-temperature characteristic of some clays will not permit it. Results on the fired brick are not as close, but usually agree to half a cone.

The most influential variable, so far as actual temperature of the end point is concerned, is the angle of inclination of the cone in the plaque, and the use of a template is therefore recommended. Yet according to Everhart's observations, an increase of the inclination to as much as 14 degrees is without effect on the P.C.E. value, at least in the range of cones 29 to 34, provided both the standard and the test cones are given the same inclination; this is because it influences all the cones to the same extent. But setting the cones at variable and ill-defined angles may possibly be responsible for some of the discrepancies in cone numbers that have been reported in the past.

VI. Significance of the Test

To be useful, a test must enable the observer to make confident predictions as to the behavior of the material tested. The outstanding characteristic of refractories is their rate of destruction or rate of failure. In the steel industry, the principal causes of failure, in order of importance, are (1) reaction with the oxides of iron, (2) reaction with slag, (3) flow and failure under load, (4) melting, (5) spalling, (6) irreversible shrinkage and expansion, and (7) mechanical breakage.

The P.C.E. test gives no information on the first two, but it does give a kind of composite result on (3) and (4), with perhaps a touch of (6). With (5) and (7) it is not concerned at all. Flow under load is probably the principal effect. The test certainly does not give direct information on any supposed "melting point," or even "softening point," of a refractory, for there are few refractory materials that liquefy or become soft at a sharply defined temperature. Neither does it say the last word about the ability of a refractory to carry a load at working temperatures. For full information, the P.C.E. test needs to be supplemented by a hot-load test and possibly by other informative tests, and the results of the P.C.E. test must be interpreted in the light of past experience with refractories of the same type.

Another kind of usefulness is in the control of raw materials, particularly clays. This is the use with which the author has had most frequent contact. At the fire-clay brick plant mentioned previously, the ceramic engineer supervised a large number of daily P.C.E. tests of clay samples. Without the P.C.E. test, proper blending could not be accomplished as effectively as with its aid, for experience has shown that general appearance, color, texture, and feel are not always reliable criteria. In this instance, even more than with a finished refractory, the P.C.E. of the clay must be correlated by experience with the properties of the brick as formed and fired and with its final service record.

RESEARCH LABORATORY
UNITED STATES STEEL CORPORATION
KEARNY, NEW JERSEY

* J. O. Everhart, now research professor at the Engineering Experiment Station, Ohio State University, Columbus, Ohio.

WORKS CONTROL OF UNIFORMITY OF REFRACTORIES *

BY E. R. HANNAH

ABSTRACT

The importance of control tests for individual physical and chemical properties as well as of uniformity of size and shape is discussed. The problem is divided into three parts, viz., control of (*a*) the finished product, (*b*) raw materials, and (*c*) processing materials.

I. Importance of Control Tests

The problems which confront the works or plant organization today in the manufacture of refractories are many and varied. The plant man's problems have become more complex due to new developments brought about by research. This research has resulted in the discovery and use of new raw materials as well as improved manufacturing techniques. These improvements have caused the establishment of more rigid specifications for refractories which permit less variation in properties of the lower as well as the higher grades.

Thus, from the foregoing remarks, it is quite easy to see why the works man of today considers the question of plant control to be of truly great importance. To him it is his insurance that the products of his plant will measure up to the specifications. Thus the plant man expects an adequate plant-control setup to enable him to control the individual physical and chemical properties of the refractory products as well as the control of uniformity of size and shape.

II. Main Problems of Plant Control

The problems of plant control fall under three main headings, viz., (1) the control of the finished product,

* Received May 20, 1944.

(2) the control of raw materials, and (3) the control of processing materials.

(1) Control of Finished Product

It is quite obvious that the control of the finished product is dependent to a great degree on the other two controls.

Standard tests are the yardstick or measure used. This phase of plant control is the most important because it puts the final stamp of approval on all of the work done by the works organization from start to finish.

The mechanics or routine of this phase of plant control must be flexible so that when trouble occurs changes may be made in the routine to insure adequate protection. To establish this routine, each product must be studied carefully, taking into consideration:

(1) The properties required for the particular type of service for which the product is intended; e.g., frequently in the case of superduty brick the panel spalling test is highly important, whereas the load test is of lesser importance.

(2) The type of production, i.e., whether the production is daily or monthly and in large or small quantities.

(3) The importance of the test in relation to the mentioned properties. This point will be covered later on in the value of the various tests.

After an analysis of this kind has been made, it should then be easy to determine what control tests should be made on each product and how often.

The value of the various tests used in the control of the finished product will vary, depending on the product being controlled. To the plant man, they are all valuable; some however, are more so than others. The pyrometric cone equivalent test is probably the most important because, unless P.C.E. specifications are met, we do not have the refractory that was intended regardless of other tests. This test is important in all types of refractory products.

The panel spalling test is excellent for simulating spalling conditions found in service because it gives some idea of the refractoriness of the product, some idea of the resistance to vitrification, and a rather good idea as to the permanency of volume and because it is not too costly to run.

The linear reheat test is very important on all types of refractories, owing to the nature of this test and its costs.

The control of chemical properties by the use of chemical analyses is very important in the case of high-alumina refractories, whereas it is of lesser importance in the case of high heat-duty and superduty brick.

The load test is of minor importance, as most service conditions require the brick to be exposed to heat on one side only. If, however, a brick in use is exposed to heat on more than one side, load is a factor and the load test is significant. Thus load tests may or may not be important.

The porosity test is highly important on products manufactured for use in metallurgical furnaces as well as where severe slagging conditions prevail.

The modulus test is of minor importance in all types of refractories. This test indicates bond and in some cases can be used to indicate comparative shippability.

Thus we can see that with an understanding of the specifications of the products, the planning of a definite routine, the detailed following of this plan, and the use of standard A.S.T.M. tests as a yardstick an adequate system for the control of the finished product can be provided.

(2) Control of Raw Materials

The next phase of an adequate plant-control program deals with the control of raw materials. Clays are the primary raw materials used in the manufacture of our refractories; there are other raw materials, however, which differ so widely in character and method of control that in the interest of brevity their control will not be discussed.

The plant or works man wants to know the following about the clay he is using in his products: P.C.E., chemical analyses, manufacturing shrinkage, reheat behavior, modulus, and appearance after firing.

How can he be sure of obtaining this information accurately? The problem is the same whether the clay is mined adjacent to the plant site or mined elsewhere and shipped to the plant. The first point of control is with core-drill samples; the second point is the clay face before mining; and the third, in the case of clay mined at the plant, is on the belt as the clay enters the grinding plant. In the case of clay being shipped into the plant, the third point of control is in the railroad cars as received.

The samples are taken as soon as possible, which would mean that the core-drill samples and the samples from the clay face or railroad cars are analyzed before the clays are used. This enables the plant operator to depend on these analyses entirely for the information regarding the variables of his raw materials. The samples taken off the belt entering the grinding plant are run as quickly as possible and these results are used as a double check on previous tests as well as to provide more data for trend indications.

Our core samples are taken from drillings on 50-foot centers. The clay face is sampled every 15 to 25 feet. This is done two weeks in advance of mining so that results may be available before the clay is used. Each railroad car of approximately 50 tons is sampled before unloading onto storage piles. Samples are taken from the belts entering the grinding plant at least once each day on each type or kind of clay.

In the testing of a sample, P.C.E. and chemical analyses can be made immediately. Test bars are made up and fired, then manufacturing shrinkage, reheat behavior, modulus, and fired appearance are determined. The number of samples taken and the kind of tests run depend on (1) the type of clay, (2) the products to be made, and (3) the inherent properties of clay.

What tests do we make on the samples taken? We divide our clays into two general classifications, viz., (1) plastic, semiflint, and flint clays and (2) high-alumina clays.

The samples of class 1 are tested for P.C.E., manufacturing shrinkage, reheat behavior, modulus, and appearance.

The samples of class 2 are tested for P.C.E., chemical analysis, modulus, and appearance.

(3) Control of Processing Materials

The third phase of the plant-control program, i.e., the control of processing materials, is one that to discuss in

detail is almost impossible. There are two points in this connection, however, which are very important, viz., grain size of ground materials and moisture content of dry-press mixes.

For a screen analysis, a sample is taken from every 90 tons or fraction thereof that are ground. Except in cases where difficulty is anticipated, the grinding continues while samples are being tested. Thus, after screen cloth sizes and grinding machinery setups have once been fixed, we can expect to obtain approximately the same grind from the same clays from day to day or from bin to bin. Screen analyses are used simply to indicate trends rather than to check a specific bin of clay.

The moisture content of dry-press mixes is taken for every 90 tons or fraction thereof prepared. Also once each shift (8 hours) a sample is taken from each dry press. This constitutes a check on previous moisture determination as well as any drying out that might occur during the process.

III. Control of Uniformity of Size and Shape

Up to this point, this discussion has dealt primarily with the control of the chemical and physical properties of the product. The control, however, of the size of the product has also been covered without specific attention being called to this particular phase. The key to the control of size is in the thorough control of the manufacturing shrinkage of the raw materials as well as in accurate mixing and blending of raw clays and calcined materials. The control of the uniformity of shape can be regulated only by means of a vigilant inspection program throughout the processing of materials, especially in the orming departments.

IV. Conclusion

The outlined plant-control system, which we have developed to meet our requirements, has proved to be adequate and quite satisfactory. The real value of a plant-control system is not the exposure of faulty material, because, after all, if plant control is functioning, faulty material is rare, but its real value is in indicating the trends before serious trouble arrives. We therefore tabulate our plant-control results and analyze them each month.

A successful plant-control system holds the plant organization fully responsible for the quality of the products and permits no joint responsibility with an outside department. In our own organization, our control work is done in the plant-control laboratory under the direction of the Research Department; the plant, however, furnishes all samples and is responsible for all products produced and shipped.

A. P. Green Fire Brick Company
Mexico, Missouri

SIGNIFICANCE OF THE PANEL SPALLING TEST*

By L. C. Hewitt

Abstract

The panel spalling test for fire-clay brick is simulative to service owing to the fact that one face of the furnace wall is exposed to the test conditions. The test correlates the effect of such factors as refractoriness, volume stability, structure, modulus of elasticity, and thermal expansion with the ability of a firebrick to withstand thermal shock. The panel spalling test is used with a high degree of success in controlling and developing refractories to meet service needs.

I. Introduction

Consumer and producer refractory engineers are faced with the problem of interpreting laboratory tests in terms of serviceability. A satisfactory requirement test should not reject products that are serviceable but should exclude those which are not. From this viewpoint, we, in many cases, still have a long way to go in determining the serviceability of fire-clay refractories. At times, well-meaning consumer engineers write firebrick specifications that are impossible. This is due to lack of understanding of the relation between tests and service and the limitations in combining certain properties in firebrick manufacture.

Until recent years, engineers were handicapped particularly in determining whether or not a firebrick would spall in service.

II. Water-Dip Test

The water-dip test, still being used to a minor extent, is a prediction in some cases and in others it has no significance. Primarily, it measures the ability of a brick to withstand thermal shock, without taking into consideration other factors such as surface shrinkage. Certain types of siliceous brick withstand spalling remarkably well, a fact which the water-dip test definitely fails to bring out. The panel test results on such brick tie in reasonably well with service behavior.

Refractories undergo a physical change after prolonged periods of use. These changes vary with the prevailing conditions. It was recognized that a test was needed to determine the properties of a firebrick, not as made but after it had been in service.

III. Panel Test

The panel test is based upon the principle of simulating what occurs in a furnace wall. An important correlation is that only one face is exposed to furnace temperatures. Although it does not bring into play all the service factors that may contribute to spalling, it covers more than any test conceived to date.

Before the final details of the present test were decided upon, a survey was made of the service spalling behavior of a large number of firebrick brands. The test procedure

* Received April 13, 1944; revised copy received August 4, 1944.

was then developed in such a way as to provide results that could be correlated with known service action. This survey was made possible by the cooperative effort of manufacturers in furnishing confidential information to Mellon Institute. These data served as guides to the proper temperatures and limits of loss for various conditions of service and for distinguishing between high heat-duty and superduty brick.

Phelps[1] has discussed the factors that cause spalling. These are mechanical, structural, and thermal.

(1) Mechanical Spalling

Mechanical spalling is due to pinching and to abrasion of various kinds. Improper provision for expansion, or warpage, of the refractory itself causes pinch spalling. Abrasion spalling is the result of mechanical abuse. The use of a clinker bar or the jar that a malleable furnace bung receives in handling illustrates the point.

The panel test does not evaluate the ability of a refractory to withstand mechanical spalling. Fortunately the modulus-of-rupture test provides an index to cover such cases.

(2) Structural Spalling

Structural spalling is quite likely the main cause of spalling in most furnace operations. It is caused by faulty structure of the refractory, such as laminations, and to changes in structure that the refractory undergoes in service. The exposed face will vitrify, and the degree of vitrification depends upon the refractoriness of the brick, furnace operating temperatures, furnace atmosphere, and the nature of slags or fluxes that may be present.

This vitrification is usually accompanied by shrinkage which, if excessive, will cause a separation of the vitrified layer from the body of the brick. It is likely, however, that the actual separation along the lines of shrinkage cracks is often influenced by thermal shock. Shrinkage cracks may develop even though vitrification does not occur. High-alumina brick formerly were prone to fail in this manner. Present-day brick have greater volume stability.

The panel test produces structural spalling through the preheat to which the brick are subjected. It does not produce the effect of slags or fluxes, though it would be highly desirable if such were the case. Some work has been done on this particular phase. The difficulty of the problem is apparent when one visualizes the variety of slags present in boiler furnaces alone. Any development in this direction would be regarded as supplementary to the present test rather than a replacement.

(3) Thermal Spalling

Thermal spalling results from expansion or contraction strains caused by rapid heating or cooling. In the panel test, through alternate heating and cooling, the properties of a brick that influence the results are brought into operation. These factors are reversible thermal expansion, modulus of elasticity or flexibility, mechanical strength, plastic flow, and thermal conductivity.

Surface shrinkage, due to vitrification, was mentioned in connection with structural spalling. This vitrification may also cause thermal spalling because of a difference in the coefficient of expansion of the vitrified layer and the body of the brick.

IV. Significance

The panel test is flexible in that the preheat temperature and its duration, as well as the heating and cooling cycle, can be varied to meet conditions of service.

Thus, all in all, the panel test is comprehensive and simulative of many industrial furnace operations. Malleable furnace bungs represent a close correlation. By means of the panel test we are able to predict reasonably well whether a given bung brick will be serviceable or not. In fact, the panel test was instrumental in developing the present type of bung brick on the market. Superduty brick likewise owe their present development to the panel spalling test and are almost invariably used where spalling conditions are severe. Such instances of use are many, e.g., boilers and heating furnaces.

Manufacturers rely upon the panel test in checking and controlling the quality of their product. Many consumer specifications include the A.S.T.M. limits.

In conclusion, it may be said that the panel test is a measurement of the combined factors of spalling resistance, volume stability, and refractoriness of the material under test.

Laclede-Christy Clay Products Company
St. Louis 16, Missouri

[1] S. M. Phelps, "A Nontechnical Description of Spalling Action," *Amer. Refrac. Inst. Tech. Bull.*, No. 24, 7 pp. (June, 1928); *Ceram. Abs.*, **7** [11] 761 (1928).

NOTES ON CONSTITUTION OF PYROMETRIC CONES*

By William J. McCaughey and John M. Neff

I. Introduction

White pyrometric cones are composed of orthoclase, calcite, clay, and quartz (flint) in varying proportions to form a series with deformation temperature in graded steps. The most difficult problem in the past has been to reproduce the orthoclase used in cone manufacture. It is desirable to consider the norm composition of orthoclase rather than its actual composition. Hintze[1] gives detailed chemical analyses of orthoclase in which considerable variation in composition is shown, particularly with respect to the K_2O/Na_2O ratio. This variation is due not only to an actual variation in composition of the mineral, but to the fact that most commercial feldspars are actually perthite, in which inclusions of albite are imbedded in a host of orthoclase (microcline). This intimate mixture of the two feldspars is due to the exsolution of the albite from the homogeneous feldspar (solid solution) formed at high temperatures.[2]

* A contribution by the Edward Orton, Jr., Ceramic Foundation, Columbus, Ohio. Revised copy received July 19, 1944.

[1] Carl Hintze. Handbuch der Mineralogie, Vol. 2, pp. 1406–1417 (1897).

[2] P. P. Ewald and C. Hermann. Strukturbericht, 1926. For X-ray diffraction evidence see p. 464.

The amount of albite intergrowth varies with the original composition of the orthoclase.

As the raw materials in the cone are heated, the kaolin ($Al_2O_3 \cdot 2SiO_2 \cdot 2H_2O$) reacts with whiting ($CaCO_3$) to form anorthite ($CaO \cdot Al_2O_3 \cdot 2SiO_2$), the calcium feldspar.

$$CaCO_3 + Al_2O_3 \cdot 2SiO_2 \cdot 2H_2O = CaO \cdot Al_2O_3 \cdot 2SiO_2 + CO_2 + 2H_2O.$$

In cone 10, the kaolin and the whiting are in molecular proportions to form anorthite.

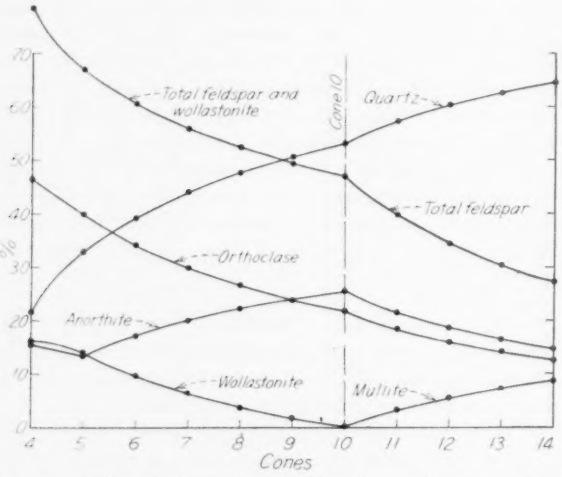

FIG. 1.—Mineralogical compositions (norms) of cones 4 to 14.

In the series below cone 10, the whiting is in excess of the clay added, and wollastonite is formed by the reaction of excess calcium carbonate with quartz

$$CaCO_3 + SiO_2 = CaO \cdot SiO_2 + CO_2.$$

Above cone 10, the clay is in excess, and mullite is formed from excess clay

$$3Al_2O_3 \cdot 2SiO_2 \cdot 2H_2O = 3Al_2O_3 \cdot 2SiO_2 + 4SiO_2.$$

This divides the white cones into two series, viz., cones 4 to 10 and 10 to 14.

The mineralogical compositions (norms) of cones 4 to 14 are shown in Fig. 1. The slopes of the curves show that there are two distinct series of cones.

Cone 9 contains orthoclase and anorthite (calcium feldspar) in equal amounts. Cones below 9 (4 to 8) show orthoclase (potash feldspar) exceeding the anorthite in amount. Cones above 9 (10 to 14) show anorthite to be in excess of the orthoclase.

Cones 4 to 9, inclusive, in their norm mineral composition include wollastonite, a mineral actively contributing to fluxing. Cones 11 to 14, inclusive, show mullite, a refractory phase contributing to a very limited extent (2%) in the formation of a molten phase. Cone 10 is a transition cone and contains neither mullite nor wollastonite in the norm composition.

II. Fluxing Effect at High Temperatures of Minerals

As the cones perform in service, equilibrium is never completely reached. Equilibrium would be enhanced by the use of finer fluxing constituents and by thorough mixing. To insure complete equilibrium, repeated firing with intermediate regrinding would be necessary.

An examination of the thin section of a deformed cone shows the presence of large amounts of undissolved quartz in angular fragments with little or no evidence of attack by solution. From this, it is clear that for the most part the quartz of the pyrometric cone acts as a refractory (unyielding to solution) and lies imbedded in an otherwise glassy matrix. It is probable that only the very small particles of quartz (10 microns or less) are available for the fluxing reaction.*

Cones were made in which all of the quartz was removed and then tested against standard cones with normal quartz content. The cones without quartz additions were generally $^1/_2$ cone more refractory than those containing quartz, showing that a small part of the quartz must be effective in the fluxing reaction, and it would appear that only that small fraction of the quartz which has the smallest diameter and hence the greatest net surface and the greatest distribution is effective as a flux.

The mineral constituents of the pyrometric cones can be arranged arbitrarily in the following order of decreasing availability as fluxing compounds: albite, orthoclase, wollastonite, anorthite, quartz, and mullite.

Mullite up to 2% is a flux, but in amounts beyond that it is a refractory constituent. If a large amount of anorthite is present, not all will be available for fluxing; the excess will remain undissolved.

At or slightly above their melting temperatures, these minerals have viscosities which differ greatly. Data regarding the viscosities of the feldspars were obtained from the work of Kani and Kôzu in the *Proceedings of the Imperial Academy [Tokyo]*, Volumes 10 and 11 (see pp. 375–78 this issue). Supplementary data were obtained from the work of McCaffrey,[3] Vogt,[4] and Herty.[5]

III. Effect of Crystallization on the Viscosity of Melts

Kôzu and Kani state:

From these curves it can be seen that the viscosities of an homogeneous melt at different temperatures can be practically expressed by a straight line (log curves) while, when the primary phase commences to crystallize in the melt, the curve changes its trend suddenly, caused by in-

* The unavailability of quartz in ordinary whiteware bodies for fluxing is not true under continued reducing conditions. With this latter condition, quartz particles are found frequently with an envelope of a clear glass of low index of refraction (1.465) imbedded in a glass with index of refraction close to 1.50. The matrix glass contains crystals of mullite, but the glass of low index is clear and free from mullite and its boundaries are sharp against mullite-bearing glass. The quartz particles imbedded in the clear low-index glass occupy a very small area and are rounded as if they were being taken into solution.

[3] McCaffrey, Lorig, Goff, Oesterle, and Fritsche, "Determination of Viscosity of Iron Blast-Furnace Slags," *Trans. Amer. Inst. Mining Engrs.*

[4] (*a*) J. H. L. Vogt, "Physical Chemistry of the Crystallization and Magmatic Differentiation of Igneous Rocks, III," *Jour. Geol.*, **29**, 515–39 (1921); *Ceram. Abs.*, **1** [7] 180 (1922).

(*b*) Part V, *ibid.*, **30**, 611–30 (1922).

(*c*) Part VI, *ibid.*, pp. 659–72; *Ceram. Abs.*, **2** [5] 107 (1923).

[5] C. H. Herty, Jr., F. A. Hartgen, G. L. Frear, and M. B. Royer, "Temperature-Viscosity Measurements in the Systems CaO–SiO_2 and CaO–SiO_2–CaF_2," *U.S. Bur. Mines. Repts. Investigations*, No. 3232, 31 pp. (1934); *Ceram. Abs.*, **13** [10] 270 (1934).

TABLE I

VISCOSITY OF MELTS OF MINERAL COMPOSITIONS AT DIFFERENT TEMPERATURES IN POISES

(°C.)	Orthoclase	Anorthite	Albite	Wollastonite
1100			33,880,000	
1125				
1150				
1175				
1200				
1225				
1250				
1275				
1300			1,097,000	
1325			714,300	
1350			434,700	
1375			283,500	
1400	10,220,000		177,500	
1425	5,557,000		114,100	
1450	4,004,000	MC 111		
1475				
1500		MC 60.5		
1525				
1550		K 106.9		2.73 MC
1575		K 87.9		
1600				2.40 MC
1625				
1650				2.38 MC

TABLE II

VISCOSITY IN POISES OF ARTIFICIAL MELTS CORRESPONDING TO VARIOUS MIXTURES OF ALBITE (AB) AND ORTHOCLASE (OR)

	100% Or	80 Or* 20 Ab	60 Or* 40 Ab	40 Or* 60 Ab	20 Or* 80 Ab	100% Ab
1300						1,097,000
1325					1,658,000	714,300
1350			2,005,000	1,510,000	1,053,000	434,700
1375		2,947,000	1,165,000	1,053,000	690,400	283,500
1400	10,220,000	1,684,000	763,100	637,700	454,600	177,500
1425	5,557,000	1,046,000	469,350	427,400	268,500	114,100
1450	4,004,000	700,500	321,100	250,500	178,600	

* Kôzu and Kani. (See also Fig. 2 on following page.)

creasing friction produced by increasing amount of crystals in the residual melt, as is seen in the many curves in the diagram. If the crystallization velocity of the primary phase in the melt at its melting point is rapid, the rotation of the cylinder attached to the instrument stops in the neighborhood of this temperature by the enormously increased friction produced by mineral aggregation, as in the cases of anorthite and diopside.

Kani specifically mentions anorthite, but does not specify the same with the melts corresponding to feldspar, albite, or orthoclase.

Further evidence of this abrupt change in viscosity of melts is shown by Herty in Fig. 3 (see p. 378.) Comparison of viscosity of melts at 1600° and 1550°C. shows that at 1550°C., close to liquidus at composition between 47% CaO and 54% CaO, viscosity rises abnormally, whereas at 1600° and 1650°C., which have higher degrees of superheat, there are no such abnormalities.

Stewart[6] believes that before crystallization begins there is an association of molecular species into larger groups.

The viewpoint of this laboratory is that every liquid contains a myriad of small groupings of molecules produced by forces acting between them, the groups being neither perfect in form nor permanent. . . . Viscosity is that of groups and of unorganized molecular arrays between them, and this does not depend directly upon the structure of a single molecule.

At a meeting of the American Physical Society in Columbus, Ohio, Professor Stewart indicated that as one approaches saturation (liquidus) the degree of association of the molecules increases toward the highest degree of association, the crystal.

The effect of these associated groups or of submicroscopic crystals on the viscosity of the melt should be to increase the viscosity; particularly would this be so if the system has a predominant constituent which crystallizes readily.

TABLE III

VISCOSITY IN POISES OF MELTS CORRESPONDING TO ALBITE, ANORTHITE MIXTURES

	Plagioclase Series					
	Ab 100	Ab 80 An 20	Ab 60 An 40	Ab 40 An 60	Ab 20 An 80	An 100 MP = 1555
1250		1,159,000				
1275		468,300				
1300	1,096,000	322,900				
1325	714,300	183,600	29,900			
1350	434,600	114,800	19,030			
1375	283,400	66,800	12,210			
1400	177,500	43,320	7,794			
1425	114,110	27,500	5,077	1593		
1450				1005		
1475				648	236.5	
1500				438	185.8	
1525					156.2	
1550					132.2	106.9
1575						87.9

[6] G. W. Stewart, "Theory of X-Ray Diffraction in Liquids," *Phys. Rev.*, **32**, 558–63 (1928); pp. 562–63.

VISCOSITY PHENOMENA OF THE SYSTEM $KAlSi_3O_8$–$NaAlSi_3O_8$ AND OF PERTHITE AT HIGH TEMPERATURES*

BY KÔICHI KANI

Electrotechnical Laboratory, Ministry of Communications, Tokyo
(Communication by S. Kôzi, M.I.A., October 12, 1935)

"Using the same instrument with which the viscosities of basalt glasses[1] were previously determined by the author, the same property of the binary system $KAlSi_3O_8$–

* From *Proc. Imp. Acad.* [Tokyo], **11** [8] 334–36 (Oct., 1935); abstracted in *Ceram. Abs.*, **16** [7] 224 (1937).

[1] Kôichi Kani, "Measurement of the Viscosity of Basalt Glass at High Temperatures, II," *Proc. Imp. Acad.* [Tokyo], **10**, 79–82 (1934).

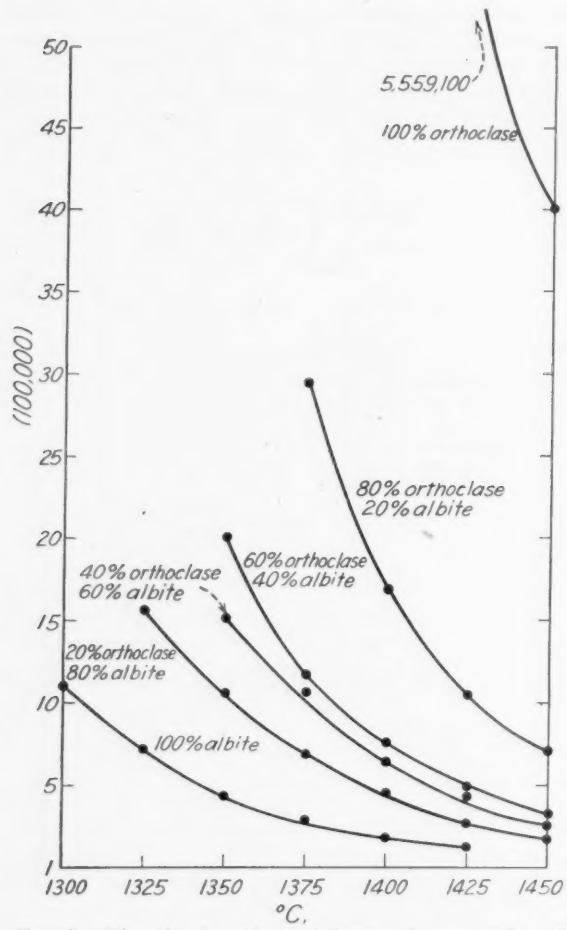

FIG. 2.—Viscosity in poises of glasses of composition of mixtures of orthoclase and albite. (Kôzu and Kani.)

$NaAlSi_3O_8$, and also that of a natural perthite, whose locality is Ishikawa, Prefecture Fukushima, were measured under the same condition.

"The instrument is a cylinder-rotation type, as already described in these *Proceedings*,[2] and the viscosity of the material under examination can be by the calculation of the equation

$$\log \eta = 1.3252 \log k\ 10^2 + 0.7217 \qquad (1)$$

in which η is the viscosity and k is equal to $(W' - k')/S$; W' and S are the load in grammes and the revolution per minute, both being experimentally obtained in using this apparatus.

"Six different chemical compositions of the charges belonging to the binary system $KAlSi_3O_8$–$NaAlSi_3O_8$ were taken for the present experiment; they are $KAlSi_3O_8$ (Or), $NaAlSi_3O_8$ (Ab), 80 wt. % of Or and 20 wt. % of Ab, 60 wt.% of Or and 40 wt. % of Ab, 40 wt. % of Or and 60 wt. % of Ab, and 20 wt. % of Or and 80 wt. % of Ab.

"For the formation of these glasses, SiO_2 was obtained from transparent quartz, whose fine powder was purified by HCl, and Al_2O_3, K_2CO_3, and Na_2CO_3 were those prepared by the Kahlbaum Co. The refractive indices of these glasses for sodium ray, determined by a total reflectometer, are as seen in Table I. Comparing the refractive indices of Or- and Ab-glasses formed in this case with those (1.485 for Or-glass and 1.489 for Ab-glass) of the same compositions determined by Morey and Bowen, we see that our results are slightly higher than the other's though the differences do not exceed 0.0015. It is evident that these differences must depend upon the variation of the chemical compositions of these charges. A trial of chemical analysis was made for Or-glass and it was seen that the rather larger differences are in K_2O and Al_2O_3, that is, in the Or-glass made in this case, K_2O is 0.20 less than the theoretical composition of Or while in the same glass Al_2O_3 is 0.33 greater than in the latter. These differences must cause the increasing of the reflective index in the glass to some extent.

TABLE I

Composition (wt. %)	Refractive index
100% Or	1.486_5
80% Or, 20 Ab	1.487_4
60% Or, 40 Ab	1.488_0
40% Or, 60 Ab	1.488_6
20% Or, 80 Ab	1.489_6
100% Ab	1.490_2

"The results of the experiment: The values of W' and S were experimentally obtained by this cylinder-rotation method and those of k and k' were obtained by the calculation of the equation $W' = kS + k'$ for different temperatures between 1450°C. and 1300°C. The logarithms of the viscosities which are obtainable by the calculation of the equation (1) are given in Table II. The change in log η referred to the temperatures applied in this experiment is shown in Fig. 1* and the change in log η referred to the chemical compositions in the binary system $KAlSi_3O_8$–$NaAlSi_3O_8$ is seen in Fig. 2. We see from Fig. 1 that the change in log η of each change can be expressed by a straight line in the range of the applied temperatures and these straight lines for a series of different compositions in the binary system are practically parallel to each other. For a constant temperature, the change in log η referred to the composition can be indicated by a more complicated curve as is seen in Fig. 2 and the inclination of its trend is most gentle in the range of concentration from 30% to 70% of Ab and is most steep for the concentration between 80% and 100% of Or.

"The viscosity of perthite: The viscosities of perthite for four different temperatures were measured as before and the results are:

Temp. (°C.)	1450	1425	1400	1375
log η'	6.0775	6.3022	6.5794	6.8089

"The results are also plotted in Fig. 1 to compare with those of the artificial glasses. From the figure, we see

[2] Kôichi Kani, "Viscosity of Basalt Glass at High Temperatures, I," *Proc. Imp. Acad.*, [Tokyo], pp. 29–32; *Ceram. Abs.*, **13** [10] 257 (1934).

* Kani figures not included herein.

TABLE II

Temp. (°C.)	100% Or	80% Or	60% Or 40% Ab	40% Or 60% Ab	20% Or 80% Ab	100% Ab
	log η	log η	log η	log η	log η	log η
1450	6.6025	5.8454	5.5067	5.3989	5.2519	
1425	6.7448	6.0196	5.6715	5.6308	5.4289	5.0572
1400	7.0094	6.2264	5.8826	5.8046	5.6576	5.2493
1375		6.4694	6.0663	6.0225	5.8391	5.4525
1350			6.3022	6.1790	6.0225	5.6381
1325					6.2196	5.8539
1300						6.0400

that the viscosity of perthite is higher than that which we have expected from its chemical composition previously analyzed by K. Seto in our Institute, its molecular formula being given as Or 63.8 $Ab_{33.7}$ An_{25}. The refractive index of the perthite glass is 1.4875 and that of the artificial glass of 80% of Or and 20% of Ab is 1.4874. If we take only this optical property in comparing their viscosities, the results obtained by the present measurements for these two glasses may be considered as showing an agreement of a satisfactory order, that is, log η in the range of temperatures from 1375°C. to 1450°C. varies in the limits of about 5.8 and 6.8."

VISCOSITY MEASUREMENTS OF THE TERNARY SYSTEM DIOPSIDE–ALBITE–ANORTHITE AT HIGH TEMPERATURES*

By Shukusuké Kôzu and Kôichi Kani

Institute of Mineralogy, Petrology, and Economic Geology, Tôhoku Imperial University, Sendai
(Communication by S. Kôzi, M.I.A., November 12, 1935)

"With the same apparatus described previously,[1] the viscosities of 21 different charges indicated in the ternary diagram diopside–albite–anorthite as is seen in Fig. 1† were measured at temperatures in range between 1150°C. and 1575°C. The final results are given in Table I. In order to show the relation between the temperatures and their corresponding viscosities, Fig. 2 was drawn in grouping the charges into three kinds of the binary systems Ab–An, Ab–Di, and An–Di and one of the ternary system Ab_x–An_y–Di_z. From these curves it can be seen that the viscosities of an homogeneous melt at different temperatures can be practically expressed by a straight line, while, when the primary phase commences to crystallize in the melt, the curve changes its trend suddenly caused by increasing friction produced by increasing amount of crystals in the residual melt, as is seen in the many curves in the diagram. If the crystallization velocity of the primary phase in the melt at its melting point is rapid, the rotation of the cylinder attached to the instrument

* From *Proc. Imp. Acad.* [Tokyo], **11** [9] 383–85 (Nov., 1935).

[1] Kôichi Kani, "Viscosity of Basalt Glass at High Temperatures, I," *Proc. Imp. Acad.* [Tokyo], **10**, 29–32 (1934); *Ceram. Abs.*, **13** [10] 257 (1934).

† Kôzu and Kani figures not included herein.

Table I

Log η for 21 different charges

Temp. (°C.)	(1) Di 100	(2) Di 80 Ab 20	(3) Di 80 An 20	(4) Di 60 Ab 40	(5) Di 60 Ab 20 An 20	(6) Di 60 An 40	(7) Di 40 Ab 60	(8) Ab 40 An 20 Di 40	(9) Di 40 Ab 20 An 40	(10) Di 40 An 60	(11) Di 20 Ab 80
1425	1.8344	1.8926	1.8700	1.9599	1.9453	1.9121	2.4941	2.2417	2.0578	1.9781	3.5018
1415	1.8668										
1400	1.9031	1.9321	1.9166	2.0343	1.9887	1.9581	2.6463	2.3651	2.1211	2.0175	3.6377
1375		1.9693	1.9596	2.1142	2.0307	2.0013	2.7665	2.4867	2.2421	2.1287	3.7891
1350				2.2058	2.0803	2.0515	2.8756	2.6197	2.3396	2.4950	3.9487
1325				2.3001	2.1414	2.0921	3.0252	2.7690	2.5050	3.4000	4.0794
1300				2.4540	2.2282	2.1711	3.2153	2.9193	2.6687	3.7694	4.3086
1275				2.6361	2.3883	2.2381	3.3808	3.1059	2.8587	4.2480	4.4263
1250				2.8267	2.5536	2.6105	3.5179	3.2491	3.2469		4.6262
1225					2.7179		3.7267	3.4631			4.8461
1200							3.9860	3.6557			5.0680
1175								3.9084			5.2884
1150											5.4951

Temp. (°C.)	(12) Di 20 Ab 60 An 20	(13) Di 20 Ab 40 An 40	(14) Di 20 Ab 20 An 60	(15) Di 20 An 80	(16) Ab 100	(17) Ab 80 An 20	(18) Ab 60 An 40	(19) Ab 40 An 60	(20) Ab 20 An 80	(21) An 100
1575										1.9440
1565										1.9881
1555										2.0289
1550									2.1212	
1525				1.9910					2.1937	
1500				2.0367				2.6610	2.2690	
1480								2.8117		
1475				2.0847					2.3738	
1465			2.2008							
1450			2.2857	2.1565				3.0022		
1430			2.3620							
1425	3.0849	2.6042		2.2287	5.0572	4.4393	3.7056	3.2022		
1415			2.4588				3.7784			
1400	3.1816	2.7937	2.5533		5.2493	4.6367	3.8918			
1375	3.3480	2.9414	2.7018		5.4525	4.8248	4.0767			
1350	3.5117	3.1264			5.6381	5.0596	4.2795			
1325	3.6888	3.2976			5.8539	5.2638	4.4757			
1300	3.8764	3.5734			6.0400	5.5092				
1275	4.0739	4.1036				5.7556				
1250	4.2753					6.0641				
1225	4.5540									
1200	4.8299									
1175	5.0643									
1150										

Melting points (Geophysical Laboratory): Di = diopside 1391°C. Ab = albite 1100°C. An = anorthite 1550°C.

stops in the neighborhood of this temperature by the enormously increased friction produced by mineral aggregation, as in the cases of anorthite and diopside.

"From mineralogical and petrological points of view, as it appears to be especially interesting to know the viscosities corresponding to the melting point of mineral, the values (log η) for three kinds of the binary system stated above were obtained approximately by a graphical method and the result is shown in Table II.

"Comparing the result with the thermal properties of the same system studied by N. L. Bowen, we can see at once that no crystal phase can be obtained from its dry melt whose viscosity (log η) is larger than about 5.30, and the value of log η of albite at 1100°C. is about 3.5 times that of anorthite at 1550°C., whose viscosity is practically the same as that of diopside at 1400°C., though the former is slightly larger than the latter."

TABLE II

No. of charge	Wt. (%) Di	Ab	An	Temp. of beginning of crystallization		Viscosity (log η) corresponding to liquidus	
1	100	0	0	1391°C.	←Diopside→	1.92	83.18
2	80	20	0	1354		2.01	102.3
4	60	40	0	1310		2.35	223.9
7	40	60	0	1260		3.43	2692
11	20	80	0	1185		5.20	158,500
16	0	100	0	1100	←Albite→	7.53	33,880,000 poises
15	20	0	80	1480		2.08	120.2
10	40	0	60	1390		2.03	107.2
6	60	0	40	1278		2.18	151.4
3	80	0	20	1350		2.01	102.3
17	0	80	20	1330		5.21	162,200
18	0	60	40	1415		3.78	6026
19	0	40	60	1470		2.86	724.4
20	0	20	80	1515		2.22	166.0
21	0	0	100	1550	←Anorthite→	2.05	112.2 poises
16	0	100	0	1100		33,880,000	

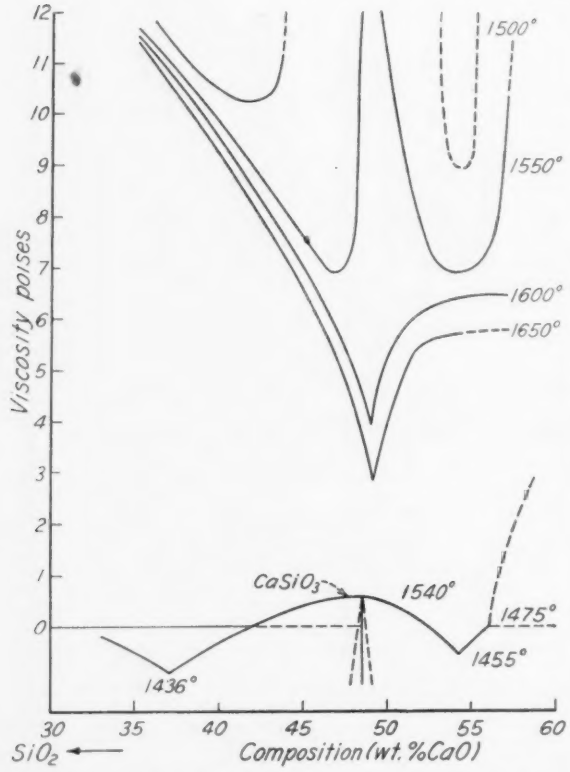

FIG. 3.—Viscosity isotherms of the system CaO–SiO_2. (Herty.)

Upstate New York Section: Sherwood Hotel, Hornell, N. Y., October 27.
Ceramic Association of New York: New York State College of Ceramics, Alfred, N. Y., October 28.

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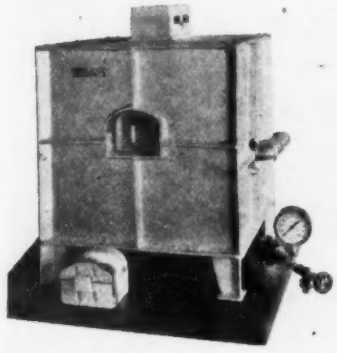

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FUME OR VAPORS FROM MOLTEN GLASSES *

By C. A. Bradley, Jr.

Abstract

Molten glasses are considered as solutions of more or less volatile constituents, particularly in regard to the vapor pressures and rates of evaporation of the more volatile ones. Applications of Henry's law and the Clapeyron equation with experimental results of Preston and Turner are cited. From these results, the amount of material lost by volatilization (disregarding losses due to "dusting" of the batch) from commercial melting units is calculated. Considerable amounts of this material should condense in the checker and flue system.

I. Introduction

In considering the processes involved in the melting of glasses, one is dealing, in large measure, with the formation and behavior of viscous liquids. Thus, fundamentally, laws which govern the behavior of substances which are liquid at ordinary temperatures may be expected to apply to molten glasses. Measurements designed to test the conformity of molten glasses to these laws are difficult, however, to obtain because of the condition of high temperature under which they must be made, and actual results on many properties are not extensive. Precise measurements have been made on such properties as viscosity, surface tension, and density of molten glasses, and these have been found to conform to the laws governing materials liquid at ordinary temperatures.

The purpose of this discussion is to call attention to the fact that molten glasses may be considered as solutions of some more or less volatile constituents. At the temperatures employed in glassmelting and working, considerable amounts of material, mainly fluxes, are vaporized from the melt. Most of the materials which thus distill off have boiling and melting points higher than those temperatures which exist in certain parts of the checker and flue systems. Considerable amounts of these materials therefore will condense out as slag or dust. The volatile constituents considered here are the alkali and the lead oxides and not the batch materials which are gaseous at ordinary temperatures, such as H_2O and CO_2.

II. Properties of Solutions

Pure liquids all exhibit a tendency to vaporize. The pressure of the vapor in equilibrium with the liquid is, of course, a function of the particular liquid and the temperature. This pressure is known as the vapor pressure. The dependence of the vapor pressure on temperature is expressed by the Clapeyron equation. An approximate form of the Clapeyron equation (assuming the vapor obeys the laws of perfect gases and that the volume of the liquid is negligible compared with that of the saturated vapor) is

$$\frac{d \log p}{dT} = \frac{\Delta H}{RT^2}.$$

p = vapor pressure.
T = absolute temperature.
ΔH = molal heat of vaporization at temperature T.
R = gas constant.

With perfect solutions, Raoult's law governs the vapor pressure of the solvent.

$$p = p_0 x_0.$$

p = vapor pressure of solvent in equilibrium with solution.
p_0 = vapor pressure of pure solvent.
x_0 = mol fraction of solvent in solution.

As the solvent is that constituent which comprises the major part of the solution, in molten glasses this would be silica. It has been shown[1] that the vapor pressure of silica at usual glassmelting temperatures is very low, particularly in comparison with other constituents of common glasses. It is thus of no practical importance for this discussion.

Henry's law, however, relates to the vapor pressure of a volatile solute in a solution, and this is of more interest. This law is

$$p = kx.$$

p = vapor pressure of solute in equilibrium with solution.
x = mol fraction of solute.
k = some constant, depending on nature of solute and on temperature.

It is most probable that, in any melting unit, the solution (molten glass) is not in equilibrium with the atmosphere above it. In the case of continuous tanks, the gases sweeping over the melt are usually unsaturated with respect to the volatile constituents and the constituents which vaporize will be carried on out of the furnace. Henry's law thus merely means that the higher the concentration of the volatile constituent in the solution, the higher its vapor pressure and the more rapidly at any given temperature it will be lost from the solution.

The approximate Clapeyron equation indicates that the variation of vapor pressure with temperature will be of the form

$$\log p = A - \frac{B}{T}.$$

p = vapor pressure.
A and B = constants.
T = absolute temperature.

As the amount of material volatilizing in any given time is proportional to the vapor pressure (assuming also that the time is short enough so that the composition of the surface from which volatilization occurs does not materially

* Presented at the Forty-Sixth Annual Meeting, The American Ceramic Society, Inc., Pittsburgh, Pa., April 5, 1944 (Glass Division). Received April 28, 1944.

[1] Eric Preston and W. E. S. Turner, "Volatility of Silica," *Jour. Soc. Glass Tech.*, **18** [71] 222–24 (1934); *Ceram. Abs.*, **14** [4] 102 (1935).

change), it too should show a similar dependence upon temperature.

The actual experimental work which has been done on these questions as reported in the literature is not extensive. The major share has been done by Preston and Turner[2] and their co-workers. It is their work which will be quoted from most extensively. Their original papers should be referred to for details. It is not the purpose of this discussion to comment on the part of their work which deals with the possible existence of compounds in the molten glass but to use some of their results to show what is happening in large commercial melting units.

The glasses studied by these investigators were potash-silica, soda-silica, and lithia-silica glasses (these over a wide range of compositions) and a commercial alkali-lead oxide-silica glass, a commercial soda-lime-silica glass, and a synthetic soda-lime-silica glass without and with varying amounts of salt cake.

The general results of these studies on the rate and amount of volatilization and the vapor pressures of the volatile constituents may be stated as follows:

(1) At any given temperature, the amount of volatilized material (during the early part of the heating period) was proportional to (*a*) the concentration of the volatile substance in the melt and (*b*) the exposed surface area of the melt.

(2) The dependence of the rate of volatilization on temperature was of the form of the Clapeyron equation.

(3) Measurements on the vapor pressures followed (1) (*a*) and (2).

III. Alkali-Silica Glasses

For the simple alkali-silica glasses containing the same molecular proportions of alkali, they found that the rate of loss from the melt in actual weight of material volatilized was in the order $K_2O > Na_2O > Li_2O$. The rate of loss in number of mols volatilized was in the order $K_2O > Li_2O > Na_2O$.

IV. Alkali-Lead Oxide-Silica Glass

Preston and Turner found with the alkali-lead oxide-silica glass (SiO_2 55.57, PbO 29.83, Na_2O 5.18, K_2O 7.60, R_2O_3 1.29%) that by far the most volatile constituent was the lead oxide. The determinations were made between 900° and 1400°C. At the higher temperatures, there was evidence that some alkali was lost, but this was almost negligible compared with the lead oxide. In their experiments, done in a quiescent atmosphere, they found that all of the lead oxide was volatilized from the glass in the test crucibles in 40 hr. at 1400°C. (2550°F.). It is apparent that, in a continuous tank or an open pot, the rate of loss will be greater than that found by these investigators. Taking the value found by them at this temperature and converting to other units, we find a rate of loss of 0.76 oz. per sq. ft. per hr. or 1.14 lb. per sq. ft. per day at 1400°C. At 1300°C. (2375°F.), the corresponding loss would be 0.447 lb. per sq. ft. per day. For a tank with a melting end of 400 sq. ft. and a working end of 150 sq. ft., and assuming one half of the melting end is not covered with melting batch, i.e., the half toward the bridgewall, with a melting-end temperature of 1400°C. and a working-end temperature of 1300°C., the lead loss due to volatilization only would be 295 lb. per day.

Now consider what happens to the lead oxide. Compound formation with combustion products (CO_2, SO_2, etc.) from the fuel is unlikely as these lead compounds decompose at temperatures lower than those which exist in most parts of the checker and flue system. Lead oxide itself has a melting point of 888°C. (1630°F.), which is higher than that existing in some parts of the flue system. Data are lacking on the boiling point of lead oxide, but it may reasonably be assumed that part of the lead oxide will condense as a molten slag and part will deposit as a dry solid. Where in the flue system and at what actual temperatures condensation takes place will depend also on the degree of saturation of the flue gases with lead oxide vapors.

In the figure of 295 lb. per day, the material has been assumed (as by Preston and Turner) to be entirely lead oxide. Their data indicate that part of this consists of sodium and potassium oxides. These oxides can combine with carbon and sulfur oxides in the flue gases to form stable compounds at temperatures higher than those existing in parts of the checker and flue system. Part of these compounds will therefore also condense.

As the loss from the melting batch is probably as great as that considered from the molten glass itself, the rear half of the melting end would lose by volatilization an additional 228 lb. per day. Thus the losses due to volatilization only are approximately 500 lb. per day or one ton every four days. These figures are conservative, as the experimental data upon which they are based were obtained under conditions less favorable for volatilization than those existing in a tank.

V. Soda-Lime-Silica Glasses

Studies were made by Preston and Turner on two commercial soda-lime-silica glasses, as well as some synthetic glasses of approximately the same composition. All of the glasses had about the following composition: SiO_2 73, Na_2O 16, CaO 8.75, As_2O_3 0.06 to 0.22, and SO_3 0.25 to 0.30%. They found rather marked differences (at 1400°C.) in the rates of volatilization early in the heating with more or less equal rates after about 100 hr. of heating. It was believed that the presence of the arsenic and sulfate caused the initial losses to be high. Analyses of the glasses

[2] (*a*) Eric Preston and W. E. S. Turner, "Volatilization and Vapor Tension at High Temperature of an Alkali-Lead Oxide-Silica Glass," *Jour. Soc. Glass Tech.*, **16** [62] 219–39 (1932); *Ceram. Abs.*, **11** [12] 610 (1932).

(*b*) Eric Preston and W. E. S. Turner, "Volatilization and Vapor Tension at High Temperatures of the Sodium Silicate-Silica Glasses," *Jour. Soc. Glass. Tech.*, **16** [63] 331–49 (1932); *Ceram. Abs.*, **12** [3] 98 (1933).

(*c*) Eric Preston and W. E. S. Turner, "Volatilization from Potassium Oxide-Silica Glasses," *Jour. Soc. Glass Tech.*, **17** [66] 122–44 (1933); *Ceram. Abs.*, **13** [2] 34 (1934).

(*d*) Eric Preston and W. E. S. Turner, "Volatilization of Lithium Oxide at High Temperatures from Lithium Oxide-Silica Glasses," *Jour. Soc. Glass Tech.*, **18** [70] 143–68 (1934); *Ceram. Abs.*, **14** [1] 11 (1935).

(*e*) Eric Preston and W. E. S. Turner, "Volatilization of Lead Oxide from Lead Oxide-Silica Mixtures," *Jour. Soc. Glass Tech.*, **19** [76] 296–311 (1935); *Ceram. Abs.*, **15** [6] 178 (1936).

(*f*) Eric Preston, W. E. S. Turner, and Horace Laithwaite, "Volatilization of Sulfate from Soda-Lime-Silica Glasses," *Jour. Soc. Glass Tech.*, **20** [79] 127–38 (1936); *Ceram. Abs.*, **16** [1] 16 (1937).

These papers contain references to other work on volatilization.

after prolonged heating showed that all of the SO_3 and most of the arsenic had been lost.

A synthetic glass was prepared containing 73.35 SiO_2, 9.9 CaO, 15.95% Na_2O, and no sulfate or arsenic. For the first 20 hr. of heating at 1400°C., the loss due to volatilization was 1.7 mg. per sq. cm. This was from one half to one fourth of the rate for the glasses which contained arsenic and sulfate. They also found that the initial rate of volatilization followed the vapor-pressure law in regard to dependence on temperature, i.e., the plot of log (rate) vs. $1/T$ was a straight line. The results also indicated that the alkali was the only volatile material and that the initial rate of loss was only about one half that for a simple soda-silica glass of the same alkali content.

The effect of the presence of sulfate was studied on glasses of the base composition SiO_2 74, CaO 10, and Na_2O 16% with sulfate contents varying between 0.31 and 0.83%. The results showed that the initial rates of loss were in the order of the sulfate concentration, the temperature dependence was according to the vapor-pressure law, and that the loss of alkali was greater than for a soda-lime-silica glass containing no sulfate. The initial rate of loss of alkali (first 20 hr. of heating and correcting for loss of sulfate) was 3.6 times as great for the glass containing 0.83% sulfate as for the similar glass containing no sulfate.

Consider now a tank of 600 sq. ft. of melting area. The melting-end temperature will be about 1450°C. (2640°F.). At this temperature, the loss from this soda-lime-silica glass containing originally 0.83% SO_3 is 0.024 lb. per sq. ft. per day or 14.4 lb. per day from the melting end.

If the working end is operated at 1300°C. (2375°F.), the rate of loss is about 0.0082 lb. per sq. ft. per day. For a working end, 200 sq. ft. in area, this would amount to 1.64 lb. per day. The total volatilization loss would be 16.04 lb. per day. This amount of material is much smaller than that occurring in the melting of high-lead glasses. The actual amount of volatilization taking place, however, is probably much greater. The alkali oxides will be carried out through the checker and flue system of the furnace. Even at 16 lb. per day, the amount of sodium oxide going into the flue systems amounts to one ton of this raw flux every four months. It must be remembered that this volatilization will take place even though "dusting" of the batch is completely eliminated, either by special methods of charging the furnace or by briquetting the batch.

Turner[3] has published a note about the effect of this volatilization of alkali when the fuel being used in the furnace was relatively high in sulfur content. He observed deposits of sodium sulfate around the cooler parts of a furnace where there were joints or sightholes in the superstructure. In other cases, blobs of sodium sulfate occurred as inclusions in articles of glassware even though no salt cake was used in the batch. In two cases, a layer of molten sodium sulfate formed on the working end surface and occasionally had to be drawn off. The tanks were fired with producer gas, and, when the sodium sulfate was most troublesome, it was found that the sulfur content of the coal ranged from 1.7 to 3.2%.

In the last few years, there has been an increasing use of oil as fuel for glassmelting furnaces. The heavy oil used for fuel contains usually about 0.5 to 0.7% sulfur. If the tank (cited previously) was melting 100 tons of glass per day, at a fuel consumption of 75 gal. per ton, the fuel used per day would be 7500 gal. or 56,000 lb. of oil per day. At 0.6%, this amount of fuel would contain 336 lb. of sulfur, which would form 672 lb. of SO_2 or 840 lb. of SO_3 for possible combination with any alkali oxides. There is an ample amount of sulfur oxide to combine with the sodium oxide volatilized, as 336 lb. of sulfur are equivalent to 1495 lb. of sodium sulfate.

VI. Other Glasses

The published literature does not contain similar data obtained on other types of glasses. From a volatilization standpoint, the two most important are, no doubt, the alkali-borosilicates and the fluoride opals.

Regarding the former, the work of Cole and Taylor[4] gives data on the vapor pressures of molten boric oxide, sodium metaborate, and sodium tetraborate. These investigators found that the vapor pressure of the metaborate was by far the largest of the three in a dry atmosphere. The high volatility of boric oxide in the presence of water vapor is well known. In the case of alkali-borosilicate glasses, the amount of volatilization lies probably somewhere between the alkali-lead oxide-silica and the soda-lime-silica glasses.

In the case of the fluoride opals, alkali and fluorine are both volatilized. In addition, there exists the possibility of losing silica due to the formation of SiF_4, which is highly volatile.

VII. Conclusion

The work of Preston and Turner has been cited to show that molten glasses behave as solutions of some more or less volatile constituents. These constituents lost by volatilization from the glass bath pass out through the checker and flue systems of the furnace where they may be deposited as "slag" or "dust." These losses are in addition to those due to "dusting" which may occur when charging the furnace.

Corning Glass Works
Corning, New York

[3] W. E. S. Turner, "Formation of Sodium Sulfate in Glass Furnaces and Defects Arising Therefrom," *Jour. Soc. Glass Tech.*, **17**, 22–24 (1933).

[4] S. S. Cole and N. W. Taylor, "System Na_2O–B_2O_3: IV, Vapor Pressures of Boric Oxide, Sodium Metaborate, and Sodium Diborate between 1150° and 1400°C.," *Jour. Amer. Ceram. Soc.*, **18** [3] 82–85 (1935).

O.C.I.A. AUTUMN MEETING

The annual autumn meeting of the Ohio Ceramic Industries Association will be held October 20 and 21, 1944, in Columbus, Ohio.

Reception, American Ceramic Society Headquarters, 5:00 p.m., Friday, October 20, given by President Edwin Henry Fritz for Harry D. Callahan, President of O.C.I.A., and introducing Charles Sidney Pearce, American Ceramic Society Associate Secretary.

...47th Annual Meeting...
The American Ceramic Society, Inc.,
Hotel Statler, Buffalo, N. Y.,
April 15-19, inclusive, 1945
All Divisions Meeting Simultaneously

MODULAR MASONRY*

By Harry C. Plummer and E. F. Wanner

I. Introduction

In the paper "Modular Size of Clay-Products Units" presented at the 1943 Annual Meeting of The American Ceramic Society,[1] the writers reviewed the development of the modular movement and proposed modular sizes for clay-products units. The purpose of this paper is to report to the industry the progress that has been made during the past year in the development of modular standards and to discuss a tentative specification for modular sizes of structural clay products.

As indicated in the 1943 paper, the American Institute of Architects and the Producers' Council are joint sponsors of ASA Project A62 for the Coordination of Dimensions of Building Materials and Equipment. In addition to sponsoring this project, the Executive Committee of the AIA has endorsed modular planning and is recommending to its local chapters that, wherever possible, postwar construction be designed on a modular basis. The Producers' Council has also endorsed the movement and has included the production of modular products as an important item in its postwar program. Both sponsors have appointed a joint committee to encourage the use of modular design by architects and the development of modular products by building-materials manufacturers.

Since the last report, the concrete masonry industry has endorsed modular planning and has also agreed to furnish modular concrete masonry units for postwar construction. The Technical Committee of the Steel Window Institute has been studying a proposal for standardizing steel-sash dimensions on a modular basis. The National Door Manufacturers Association and the Wood Window Institute are also studying modular sizes for their products and, although none of these groups has as yet proposed an application standard fixing modular sizes for its products it is safe to assume that windows and doors conforming to modular masonry will be available for postwar construction.

In the opening statement of the paper last year, the writers stated, "In the opinion of many informed observers, architects, contractors, and manufacturers, the standard size of postwar building materials will be modular and an increasing number of buildings will be built from modular designs." Indications that this prediction will be fulfilled are much stronger today than they were a year ago. The design of New York City's huge public works program is proceeding on a modular basis. The modular design of one large hospital has already been completed and another is being developed. These two structures alone are estimated to cost more than 7 million dollars and the total estimated cost of modular designs that may be expected to emanate from this one source exceeds 150 million dollars. Intensive interest in modular planning is evidenced by the larger architectural companies who are now engaged in preparing plans for postwar construction, and the Federal Housing Agencies and representatives of the Public Buildings Administration are following the movement closely. The press has taken up the banner for modular design and numerous articles have appeared in *Architectural Forum* and other trade magazines explaining modular planning and urging its adoption.

The Proposed American Standard Basis for the Coordination of Dimensions of Building Materials and Equipment† and the Proposed American Standard Basis for the Coordination of Masonry, which were in process of preparation in 1943, have been submitted to the Sectional Committee for comment preliminary to final adoption and the engineering staff of the Structural Clay Products Institute has prepared a tentative specification for Modular Sizes of Structural Clay Products which was circulated to the industry for criticism and comment during the latter part of the year.

II. Modular Sizes

This proposed standard establishes sizes of clay-products units, standard mortar-joint thicknesses for various types and grades of products, and the permissible dimension variation for each product. It also lists the supplementary sizes required to provide 4-inch flexibility in masonry construction, i.e., the fractional sizes required to construct masonry where heights and lengths are multiples of 4 inches.

Three sizes of brick are included in the standard whose nominal dimensions are $2^2/_3$ by 4 by 8, 3 by 4 by 8, and 4 by 4 by 8 inches. The nominal dimensions of a unit are the actual dimensions plus the thickness of the mortar joint with which the unit is to be laid. For brick manufactured to be laid with $^1/_2$-inch joints, actual dimensions corresponding to the preceding sizes would be $2^1/_6$ by $3^1/_2$ by $7^1/_2$, $2^1/_2$ by $3^1/_2$ by $7^1/_2$, and $3^1/_2$ by $3^1/_2$ by $7^1/_2$ inches. The nominal sizes of clay masonry units included in the standard, defined as both solid and hollow units, range in thickness from 2 to 12 inches, in heights of 4, $5^1/_3$, 6, 8, and 12 inches, and in lengths of 8, 12, and 16 inches. Combinations of these dimensions cover practically the entire range of structural tile as now produced. This is a much larger number of units than many manufacturers would carry in their inventories and it is believed that eventually the industry can standardize on a much smaller list of sizes which will be adequate for practically all types of construction. Before doing this, however, it will be necessary to have information on the proposed modular sizes of doors and windows so that the tile sizes on which the industry finally standardizes will conform to the modular window and door sizes with the minimum number of supplementary or fractional units.

The specification provides in general that standard mortar-joint thickness for glazed brick and tile shall be $^1/_4$ inch; for smooth buff and gray brick and tile $^3/_8$ inch; and for all other products $^1/_2$ inch.

The permissible dimension variations proposed are related to the standard mortar-joint thicknesses. It is

* Presented at the Forty-Sixth Annual Meeting, The American Ceramic Society, Inc., April 4, 1944 (Structural Clay Products Division). Received July 31, 1944.

[1] See *Jour. Amer. Ceram. Soc.*, **26** [9] 307–20 (1943).

† See *Bull. Amer. Ceram. Soc.*, **22** [12] 417–18 (1943) and **23** [1] 28–31 (1944).

obvious that if a given number of units plus mortar joints are to lay up to a fixed dimension, any variation in the dimension of the units must be compensated for in the mortar joints. This means that if the average dimension of the units in a wall section varies from the standard dimension, the average mortar-joint thickness must also vary from the standard by the same amount. Owing to this relationship of actual mortar-joint thickness to actual size of unit, the tolerances for size variation must be small for units designed to be laid up in thin ($^1/_4$- to $^3/_8$-inch) mortar joints. In general, the permissible size variation plus or minus for the individual unit is not greater than the thickness of the standard mortar joint and the permissible variation of the average dimension of a shipment cannot be more than one fourth of the standard joint thickness.

The average dimension of a shipment is defined as the average dimension of a representative sample of the shipment, i.e., if 10 brick were selected from a shipment and it were found that the lengths of half of these brick were $7^1/_2$ inches and of the other half $7^3/_4$ inches, the average length of the sample would be $7^5/_8$ inches. If these brick were manufactured to lay up with $^1/_2$-inch joints, this sample would conform to the requirement of the specification that the variation of the average dimension from the standard dimension ($7^1/_2$ inches) can be not more than one fourth of the mortar-joint thickness or $^1/_8$ inch.

The specifications do not designate a method of obtaining a representative sample of a shipment and it would be difficult, if not impossible, to obtain a representative sample from a car or truck load of brick. It is believed, however, that the manufacturer can control the average dimension of his shipments from the plant by grading his products as to size as they come out of the kiln and later including in each shipment sufficient undersize units to compensate for the oversize units in the shipment. Although the limitation on variation of average dimension may not be practical to enforce as an acceptance requirement, it will serve as a guide to the manufacturer in shipping and eventually the economies resulting from the use of units whose average dimension is very close to standard will result in contractors demanding that this provision of the specification be met by the manufacturer.

As previously indicated, supplementary sizes to provide complete 4-inch flexibility are listed for all proposed sizes. For brick, the supplementary sizes are one-half and three-quarter lengths and, in the case of the nominal 3-inch-high brick, 2-inch heights. For tile, the number of supplementary units required is greater owing to the larger size of the unit. Sixteen-inch lengths require supplementary lengths of 12, 8, and 4 inches for complete 4-inch flexibility; in the larger sizes, however, the need for many supplementary lengths can be eliminated by slight adjustments in layout to fit the dimension of the masonry unit specified and it is probable that the demand will not justify stocking more than one or, at most, two supplementary lengths in each series. Other lengths that may be required on individual jobs may be obtained by cutting either the standard or kerfed unit.

III. Industry Meetings

Subsequent to the distribution of the tentative specification for modular sizes of structural clay products, the Structural Clay Products Institute arranged meetings in fourteen cities throughout the United States which covered all clay-producing centers from New England to California, with the exception of Washington and Oregon. These meetings were called to discuss modular planning, its effects upon industry, and the tentative specifications for modular sizes of clay products. The attendance at all of these meetings was representative of the manufacturers of the area and consisted of members of both the sales and production branches of the industry. At each meeting, the background of the modular movement was outlined and the attitude toward it of the architectural profession and other manufacturing groups was reported. In view of the interest in and support of this movement by all branches of the construction industry, the belief was expressed that much of the postwar construction will be designed on a modular basis. It was conceded at the clay-products industry meetings that this would be true and the discussion centered upon the requirements of the tentative specifications and the effects upon the industry of standardizing on modular sizes.

At each meeting, the first consideration was the sizes of brick, inasmuch as it was agreed that tile sizes will be largely influenced by the standard brick sizes.

At many meetings, an objection was raised to the smallest of the three brick sizes for the reason that more brick are required per 100 square feet than with the present standard and that, therefore, laying costs would be increased. This brick (actual size $2^1/_8$ by $3^1/_2$ by $7^1/_2$ inches) requires 675 per 100 square feet as compared with 616 of the present standard. It was pointed out, however, that as this size lays up three courses to 8 inches, the same as the present standard, it can be used in matching old work, thereby eliminating the necessity of stocking present standard size for additions or alterations to old construction. In addition, it provides a modular size which is popular with architects due to the 1:2:3 length, width, and height relationships which permit wide latitude in developing bonding patterns.

The second size (nominally 3 inches high) is proposed as a compromise between the $2^2/_3$-inch brick and the truly modular 4-inch brick. The 3-inch brick is slightly larger than the present standard size, requiring 600 brick per 100 square feet as against 616 of the present standard. Recent experience with the so-called "jumbo" brick, which is $2^5/_8$ by $3^3/_4$ by 8 inches, and with double brick 5 by $3^3/_4$ by 8 inches, indicates that substantial economies can be obtained through the use of the larger sizes. The 3-inch brick lays up four courses to 12 inches, and 4-inch height flexibility can be obtained through the use of rowlock headers and supplementary 2-inch heights. A possible disadvantage of this size is that there is not the simple relationship between length, width, and height which exists for the other two sizes.

The third size (4 inches nominal or $3^1/_2$ inches actual height) lays up one course to 4 inches and is the true modular brick. It is the largest of the three; 450 are required per 100 square feet of wall, and substantial economies in laying can be expected when this brick is used. It has the simple relationship, length, width, and height, of 1:2:2 and can be used in a wide variety of bonding patterns. Brick approximating this size have been used ex-

tensively in some parts of the country, notably Virginia and Southern California, where they have found ready acceptance, and it is believed that the use of this size and the masonry unit face size of 4 by 12 inches will increase in popularity.

In some areas, it was the consensus of those who attended the meetings that all modular brick sizes should be made available for postwar construction. In other areas, the opinion was expressed that modular brick should be limited to one or two standard sizes. The difficulty in establishing a single modular size for the entire industry is that, owing to variations in raw materials and methods of manufacture, all manufacturers cannot produce the $3^1/_2$-inch-high brick. This is particularly true of those manufacturers who use the soft-mud process. Obviously, it would be impossible for the industry to standardize on a size which many manufacturers cannot produce and it would seem to be short-sighted on the part of the industry to establish a single standard which would rule out sizes that experience indicates result in economies in laying.

The question was frequently raised as to whether or not architects will agree to and use a standard mortar-joint thickness. The primary objective of modular masonry and modular planning is economy and to attain this objective some degree of standardizing is necessary. Anyone wishing to use a nonstandard mortar joint could of course do so, but the economies inherent in modular design would be lost and it would be necessary to cut and fit as at present. Architects who attended several of the meetings expressed the opinion that on most industrial and commercial buildings and multiple housing, where cost is an important factor, architects will accept the standard joint thickness for which the unit has been designed

The savings which may be expected to result by the elimination of all or a part of the cutting of clay-products units in masonry construction was discussed at all meetings. Although it was generally agreed that the elimination of cutting would result in some saving, estimates as to the amount of this saving varied widely. A large masonry contractor who attended one meeting estimated that brick masons spent from 30 to 35% of their time cutting brick. Other estimates ranged downward from this figure to as low as 5 or 10%. The majority opinion seemed to be that approximately 20% of a mason's time may be used in cutting clay-products units on an average job.

Opinion of clay-products manufacturers as to whether or not it would be economical to manufacture half units or other supplementary sizes, particularly of brick, varied widely. Without taking a vote on the question, but judging from the opinions expressed, about half of the manufacturers believed that it would reduce the cost of masonry construction to furnish supplementary sizes to the contractor, whereas the other half felt that the most economical procedure would be to cut the units on the job as is done at present.

One or more plant superintendents were in attendance at practically every meeting and the manufacturing problems involved in producing modular sizes were discussed at some length. These problems naturally vary with the method of manufacture and type of raw material which definitely restrict some manufacturers as to the sizes which they can produce. It was agreed by all that there would be numerous "headaches" in changing the sizes of brick and tile. In no case, however, did the difficulties appear to be insurmountable, and the general consensus seemed to be that if the job was to be done at all, it should be done immediately after the war when inventories are expected to be at a minimum.

As the object of these meetings was to explain the purposes of modular planning and to discuss the proposed specification for modular sizes of clay-products units, no definite commitments were requested of the manufacturers who attended the meetings. All groups were requested, however, to express an opinion, either individually or as a group, as to the desirability of the clay-products industry adopting modular sizes as postwar standards and making such units available for postwar construction. The answer of an overwhelming majority to both of these questions was "Yes."

Many manufacturers, particularly those whose production is diversified, including both brick and tile, were enthusiastically in favor of modular sizes and felt that in conjunction with the adoption of the new sizes the industry could standardize on closure and jamb units and recommended details of construction, thereby materially reducing inventories.

Other manufacturers, who now produce only one type and grade of brick, endorsed the plan on the grounds that it is a progressive step which will reduce masonry costs, thereby increasing the use of clay products, and that modular sizes will be specified on important construction. For these reasons, even though the change to modular sizes may involve substantial plant changes and an increase in the number of stock items, they believe that the adoption of modular sizes is essential to the continued progress of the industry.

A few manufacturers opposed the adoption of modular sizes on the grounds that the economies to be obtained by modular planning would not justify the cost of making the change. These manufacturers represented less than 10% of the total.

As a result of this action on the part of the clay-products industry, the Structural Clay Products Institute started a series of advertisements in the October, 1943, issue of *Architectural Forum* announcing that the industry has endorsed modular planning and that modular clay products will be available for postwar construction. This action may be expected to have far-reaching results. It seems assured that modular planning and the use of modular products will reduce construction costs and that economies obtainable through the use of modular masonry will put the industry in a more favorable competitive position. Perhaps the greatest benefit, however, to the clay-products industry resulting from the modular movement is the renewed interest on the part of architects and engineers in brick and tile. Many large postwar projects are now being designed in modular masonry, and architects and engineers throughout the country are studying the adaptability of clay products to modern construction as perhaps never before in this generation.

Structural Clay Products Institute
1756 K Street, N. W.
Washington 6, D. C.

SUGGESTIONS CONCERNING POTS IN HAND PLANTS*

By Axel Ottoson and C. J. Uhrmann

Abstract

The importance of low porosity to obtain longer life and fewer cords and stones is discussed, and suggestions are presented for lowering porosity. Various methods of preheating are listed, and new pot materials and designs are described.

I. Introduction

It has long been known that a carefully controlled procedure in the arching of glassmelting pots is essential if consistently good results from these pots are to be obtained. It is common to find a great variation in the life of pots of the same make, ranging from 20 to 100 melts per pot, at the same time with inconsistent variation in the quality of the glass obtained. Investigation of available literature on the subject reveals little information. No definite data for the proper temperature and time required for the best arching could be found. Generally, pots are arched in the same type of pot arch fired with various types of fuel and, in most cases, the supervision of the firing of the pot is left to someone with enough practical experience and judgment to determine, by visual observation, the arching procedure.

If natural gas is used as a fuel, the pot arch is started off with a small, raw gas flame sufficient to deposit soot all over the pots. The amount of fuel is increased slightly from day to day until the soot is completely burned off and the temperature of the arch is raised gradually until the pots have reached a certain color and are assumed to be ready for setting. There is very little element of control in such a procedure and the results from this method are not uniform.

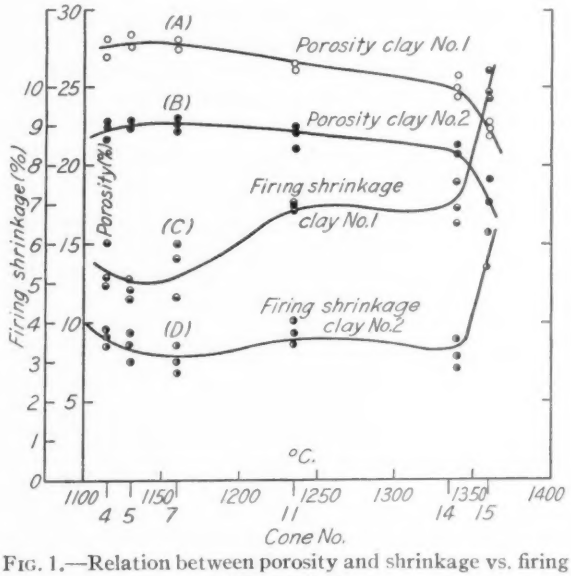

Fig. 1.—Relation between porosity and shrinkage vs. firing temperature.

Pot arches equipped with pyrometers and therefore controlled to some extent by following a predetermined temperature curve in heating the pots in many cases still produce uncertain results, so far as the life of pots and quality of glass are concerned. Over a long period of time, the various factors which are important in connection with preheating a pot were studied, and this investigation resulted in considerable change in the procedure of arching pots.

II. Laboratory Investigation

(1) Shrinkage and Porosity

The only way to approach the problem of preheating pots on an intelligent basis is to determine the firing characteristics of the clay from which the pots are made. To do this properly, prepared pot clay was obtained from two well-known makers of pots. This clay was obtained in the precise form used by the potmaker, i.e., containing the proper amount of grog and water. From this pot clay mixture 3- by 1- by 1-inch bars were prepared in sufficient quantity to carry out a number of burns. After a careful drying, the bars were fired to various temperatures under varying conditions of oxidation and reduction. Test kilns were fired to the following temperatures:

Cones	°F.
4	2129
5	2156
7	2210
11	2345
14	2534
15	2570

Throughout the procedure, sufficient measurements and weights were made on the test bars so that the porosity, firing shrinkage, and bulk and apparent specific gravity could be calculated. From these data, the firing curves for the pot clay were plotted. The curves for porosity and shrinkage are shown in Fig. 1.

The porosity curve is rather uniform at the lower cone temperatures and does not change appreciably until cone 14 (2534°F.) has been reached, after which time it drops sharply. The firing shrinkage is not nearly so uniform. It does, however, show little change between cones 10 and 14 (2300° to 2534°F.). After cone 14, the change is rapid and the clay exhibits considerable firing shrinkage. At these temperatures, the clay appears to become vitreous in character, and as such the clay would be subjected to cracking and spalling under the stress of thermal shocks, particularly that of cooling. The significance of this will be discussed later.

(2) Effect of Reducing Conditions

Some test kilns were fired under extremely reducing conditions for a major part of the burn, oxidizing conditions

* Presented at the Forty-Sixth Annual Meeting, The American Ceramic Society, Inc., Pittsburgh, Pa., April 4, 1944 (Glass Division). Received May 12, 1944.

prevailing only toward the end of the burn to reach the proper temperatures. These tests, surprisingly enough, gave results identical to tests in kilns fired exclusively under oxidizing conditions. This further indicated the ease of oxidation of the pot clays tested.

To determine the ability of this clay to oxidize properly, especially as the earlier periods of firing these pots are carried out under reducing conditions, solid clay cylinders 2 inches in diameter and 4 inches long were prepared. Twelve of these cylinders were fired at each of the following temperatures: 750°, 1100°, and 1500°F. After each of these temperatures had been reached, draw trials were made on these bars at 2-hour intervals. No difference was noted in the cross section of any of the bars withdrawn in any one burn, but the bars at 750°F. were gray in color, those of 1100°F. were a little lighter, and those of 1500°F. were definitely light buff, a color typical of refractories. From these data, it is apparent that complete oxidation of the clay progresses rapidly throughout to the extent possible at prevailing temperature and conditions.

(3) Discussion

The foregoing laboratory tests indicated that there is a definite temperature range to which glassmelting pots should be heated before being set in the hot furnace. The firing curve characteristics indicate that this temperature should be between cones 10 or 11 and cone 14, because in this temperature range the least change is taking place in the firing shrinkage, as well as the porosity of the pot. Below this temperature, there is still a sizable amount of firing shrinkage to be accounted for, and above this temperature range the firing shrinkage is even more severe. If a pot is transferred from the pot arch to the furnace at temperatures below cone 10, the ensuing shrinkage caused by the furnace heat up to cone 10 and beyond will cause the pot to shrink at a rapid rate. This shrinkage would manifest itself as a skin effect at first, taking place on the outside of the pot nearest to the furnace flame, whereas the rest of the pot will tend to remain in its partially shrunken state. This surface shrinkage is bound to develop cracks which, although not visible during pot setting, will cause planes of weakness and, in turn, early failure of the pot. Secondly, as the shrinkage progresses throughout the pot, under the full effect of the furnace heat, the pot will settle to some extent. Any obstruction to this shrinkage, such as a breast wall built up too close to the pot mouth, will cause a strain on the pot, and in turn develop cracks in front of the pot. Such an effect is probably responsible for most of the leaking pads and, generally, failures at the front of the pots.

If pots are heated in the pot arch above cone 14 (2534°F.), the vitrification is progressing quite rapidly and there is danger of over-firing, squatting, or sagging of the pot, and probably most important of all, should there be a slight interruption in the setting of the pot into the furnace, the severe cooling may cause the pot to develop cracks. It is a well-known fact that vitreous materials are more subject to cracking upon rapid cooling than non-vitreous or porous materials.

Investigation over a long period of time discloses that temperature measurements in the pot arch alone are not a reliable indication that a pot is uniformly burned, or matured. Pot arches usually are fired in such a manner that, during the earlier stages of preheating, temperatures near the roof of the pot arch are higher and graduate from there to the bottom. Even if the heat distribution throughout the pot arch later on is fairly uniform, it does not necessarily follow that the pot is uniformly burned.

Furthermore, unless thermocouples, placed in the roof of the pot arch, are periodically checked and indicators or recorders are adjusted, only relative temperatures will be established. By the use of pyrometric cones, however, the time-temperature element for proper maturing or firing of the pot clay to a predetermined degree is possible. To establish the best method in the use of pyrometric cones, a number of them were placed throughout the pot arch, and it was soon discovered how important the time element in arching of the pot really is. A cone placed on top of a pot will go down several hours before the same cone deforms at the bottom of the pot arch; consequently, a pot removed too soon would be quite properly fired in the hood, but would be still too porous in the bottom.

For example, repeated experiments disclosed that cone 10 placed alongside cone 11 on top of the pot mouth went down several hours before cone 10 bent over at the bottom of the arch under the pot, whereas cone 11 remained standing. The proper time of setting the pot was not when cone 10 deformed on top, but rather when it went down at the bottom of the arch.

It was found that the proper degree of burning the pots before setting was between cones 10 and 11. At lower temperatures and corresponding cones, the pots were not burned properly. On the other hand, pots fired above cone 14 were too vitrified and occasional checking and cracking occurred.

Observation of a large number of pots arched to various degrees of burning disclosed that if the bottom of a pot does not reach the proper degree of burning, no further appreciable burning takes place after it is set on the bench in the furnace, and subsequent failure of the pot in the bottom results.

III. Revised Procedure for Prefiring Glassmelting Pots

In view of the experimental results and the obvious indications derived from them, the following procedure has been adopted for the arching of pots. The pots are set into the pot arch in the usual manner. Between the pots four pyrometric cones are placed, viz., cones 7, 8, 9, and 10. The cone pat is placed on a brick and then other brick are built up around the cone pat and above it, leaving an open space toward the front of the pot arch so that the cones may be observed from a peephole in the pot-arch door. This is to protect the cones from impingement by direct flames. The pot-arch temperature is brought up in much the usual manner during the early part of the burn. The temperature is permitted to rise slowly until after 8 or 9 days, when cone 7 will start to bend over. From this time on, no more gas is turned on the pot arch, as there is sufficient gas now on the burners to cause cones 8, 9, and 10 to bend over within the next 24 to 30 hours. After cone 10 is reached, the pots are set in the furnace as soon as possible.

This procedure has resulted in a consistently better performance of all pots in general, the average number of melts being 74 as compared with 64 before this procedure had been adopted. Moreover, many of the pots are now re-

moved from the furnace before failure occurs to increase the life of the furnace and to facilitate easier pot setting. Most important of all is the better quality of glass obtained from the pots preheated by this procedure.

IV. Observations on Porosity

A large number of pots which had been in use and were discarded because of failures were examined carefully. In all cases where pot failure had been near or in the bottom of the pot itself, a marked difference in color and porosity of the pot shell was observed. In most cases, the bottoms of the pots were soft and spongy. The sections upward toward the hood of the pots were dense and hard. Subsequently, porosity measurements were made from various sections of pots and these measurements disclosed that the porosity of pots in general was quite high. Often a pot which had failed in the bottom after a few months of service varied in porosity from 27% near the heel to 28.5% near the center section of the bottom. These figures represent the extreme of porosity measurements and correspond to the extremes of temperatures to which various parts of the pot itself had been exposed. In other words, the bottom of the pot naturally would be the coldest, and the heel and sections of the pot nearer to the hood would be the hottest.

If the porosity of the burned pot were more uniform and lower, the life of the pot would be increased and at the same time the quality of the glass would be materially improved.

The porosity measurements are based on volume measurements. When from 27 to more than 28% of the refractories used in the pot is pore space, the clay is vulnerable to the attack of the glass, particularly during the melting period. The attack on the refractories results in cordy, stony, and sometimes off-color glass on the one hand and short pot life on the other.

The porosity of the pot may be reduced by careful sizing and blending of the grog added to the pot clays. Certain proportions of various grog sizes should be selected which will give a minimum volume of grog for a unit weight. The clay itself acts as a binder and filler between the particles. Ultimately, a clay and grog mixture could be obtained with the lowest possible porosity.

A choice of clays different from those now in use may open up a new field of clay bodies for glassmelting pots, e.g., clays with firing characteristics which would result in a much denser body. Furthermore, to secure a denser refractory which would be more impervious to the attack of the glass, the use of a porcelain-type body is suggested. A high-fire porcelain body would be the most suitable, e.g., a body maturing at cones 15 or 16 in firing. Such a material would have extremely low porosity, very high strength, and increased transmission of heat as compared with commonly used pot clays.

Numerous laboratory melts have been made using porcelain crucibles, and a remarkably slight attack of the glass took place on the refractories. Inasmuch as porcelain is more nearly like glass, such a refractory, when dissolved in the melt, would be more easily assimilated into the glass, with fewer of the defects so commonly associated with other refractories.

V. Comment on Porcelain Liners

Porcelain liners of low porosity are now already in use, and these refractories are producing glass of superior quality. Unfortunately, because of the present emergency and for reasons of security, precise information on the composition and performance of these liners is not available.

The ideal pot would be made of a porcelain-type body. This, however, would introduce drying and firing difficulties, which are not easily overcome. For this reason, the use of liners within the pots would be a more practical method of utilizing porcelain-type bodies. Such a porcelain liner could be made an integral part of the pot, being molded or formed into the pot when it is built up in the making. Furthermore, it may be more practical to make a pot in three pieces, viz., a bottom vessel, a liner of a porcelain-type refractory, and a separate hood which would fit over the two-piece bottom, the hood to be constructed along conventional lines to facilitate gathering and working of the glass. Better yet would be a one-piece porcelain bottom vessel with a suitable hood on top.

VI. Summary

These foregoing suggestions may be classified into four groups, as follows:

(1) Lowering of the porosity of the present glass pot by (*a*) proper sizing of grog, (*b*) choice of finer grog, (*c*) choice of clays, and (*d*) liners of low porosity on the inside of the pots.

(2) Deviation from the present composition of pot clays by (*a*) porcelain-type bodies and (*b*) other dense bodies using feldspar, talc, alundum, etc.

(3) Changes in design to accommodate new materials, e.g., (*a*) cast-in liners and (*b*) pots made in two or three separate parts.

(4) Changes to pots to permit better melting by a study of (*a*) glass currents in the pots and (*b*) strength versus thickness to obtain better heat transmission.

Imperial Glass Corporation
Bellaire, Ohio

ENAMEL BIBLIOGRAPHY AND ABSTRACTS

1928 to 1939, Inclusive, with Subject and Coauthor Indexes

THE AMERICAN CERAMIC SOCIETY, INC.

2525 North High St., Columbus 2, Ohio

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PRODUCTS DESIGN, A KEY TO BETTER LIVING*

By D. L. Hadley†

The dictionary defines the word "tradition" as "the transmission of information, beliefs, etc., from ancestors to posterity; something that is handed down from the past as an inherited culture." Although some American art is purely traditional or handed down from early colonial days, for the greatest part it has depended almost entirely upon imported art and culture.

A review of the history and development of art in this country shows that the American people have been "taken for a ride" by the exponents and importers of art of the European countries. All art that has been imported is not necessarily phony. Much of it is beautiful and well worth possessing, but why, as a nation that has been in existence for more than three hundred years, has it taken so long to develop an art that could be called a purely and truly American art?

This situation may be due chiefly to the fact that in the early days of our industrial progress many of the workmen and artisans employed in various industries were imported from the old countries. In the silverware industry years ago, practically all of the designers and silversmiths were French, German, and Italian, or if they were natives of this country, many of them had spent considerable time abroad studying the art of other countries.

The same condition existed in the field of architecture, especially in the design of public buildings. As a result, scattered all over the country today are buildings which are almost a photographic reproduction of the Coliseum and the Parthenon. Our religious edifices are faithful reproductions of the churches of Italy, France, England, and other countries, and the same thing applies to many of our educational institutions. In many cases, even the building materials were imported. Wealthy people, for instance, bought old castles or chateaus, had them torn down, crated up, shipped to this country, and then rebuilt. This condition cannot be attributed to any one particular group of people. It was simply the result of the thinking of those particular times, and apparently the people figured that it was much easier to import their ideas than go through the pangs of creating an art of their own.

The architecture of many foreign countries is undoubtedly very beautiful when viewed in its proper atmosphere and locale. But however beautiful some of these buildings may be in their proper historic surroundings, they are strictly phony when transplanted to the city square of a New England or Midwestern town. There is nothing beautiful about a Gothic spire erected in a large industrial city and surrounded by steelmills, hot-dog stands, and saloons.

This same thought holds true in the field of house furnishings. For many years, the wealthier class of people in this country imported the culture and art of other countries lock, stock, and barrel, and those who were unable to purchase the original had to content themselves with inferior imitations. Again, however, this is simply the result of the demands of the times. Apparently no thought had been given to developing an art and culture of our own. No one will deny that much of the furniture, tapestries, glassware, pottery, etc., of other countries are in themselves beautiful and there is no harm in people owning such objects, but for a person to fill room after room with them and insist that everyone else work themselves into a feeling of awe and reverence is asking too much.

In the past few years, the thinking and attitude of a people have changed almost entirely overnight. We are gradually learning to rid ourselves of much that is false and not in keeping with the spirit of our times. As the art of the old countries reflects the thinking and religious beliefs of their peoples, so is the new art in America beginning to reflect the change in tempo of our times. We are learning to use intelligently and honestly the machines and materials that the people of this country have created. There is increasing evidence that our artists and artisans are gradually bringing about a new order and that we are rapidly discarding our ties and dependence upon the old world.

It is only natural, in asserting our independence and attempting to build an art that is truly representative of the new world, that mistakes should be made, especially during the transition period when we were still trying to reproduce the handmade arts and crafts of one era on the machines of a new, and it did not take us long to realize that the two were not compatible. With the introduction of the artists to the machine, it was only natural that errors would be made, and only when the artists and designers began to appreciate the possibilities and the limitations of the machine did they really begin to make progress.

Many American industries, such as glass, pottery, silver, and textiles, have always employed artists or designers, and today there are few manufacturing companies who do not depend to some extent upon a trained designer to correctly interpret and develop the aesthetic possibilities of the product, and the employment of these designers in recent years has brought about a situation which apparently has caused some misunderstanding and ill-feeling on both sides. To many manufacturers, the idea of employing such a person was novel, and because of his highly specialized training, it has sometimes been difficult to place him in his true perspective in regard to the industrial picture. In many cases, he has been overpublicized and in others he frequently has failed to receive due recognition for his efforts.

The writer recently received a letter in which it was pointed out that many designers and artists in the ceramic industry have not received due public recognition. If this condition exists, it is for one of two reasons: (1) for many years it has been the policy of manufacturers not to publicize or play up any one individual or (2) those individuals referred to quite possibly have not as yet created anything worth publicizing. Many persons still belong to the

* Presented at the Forty-Sixth Annual Meeting, The American Ceramic Society, Inc., Pittsburgh, Pa., April 5, 1944 (Design Division). Received July 17, 1944.

† Design consultant, Westinghouse Electric and Manufacturing Co., Pittsburgh, Pa.

school of art for art's sake; although this may be fine and ideal in theory, it has never yet succeeded in keeping the breadbox filled. Many artists and designers in this country have felt that they have been misunderstood and unappreciated because the manufacturers refused to go into ecstasies over their artistic output. Manufacturers are engaged in a business for one purpose, i.e., to make money for the stockholders. American manufacturers are not imbued to any great extent with an altruistic concept of business. They are interested in art in industry only so long as it pays dividends and succeeds in selling more of their particular product. This applies to all industrial arts, including advertising.

The writer of the letter previously referred to mentioned specifically a glass container for a popular brand of cheese and wondered why producers of this dairy product could not be induced to identify either the designer or the maker of the glass container or both. If the manufacturer of this particular item of glassware could prove to the dairy company that by thus identifying this container it would materially increase the sale of this product, he might have a good story. The cheese manufacturer, however, is still interested in only one thing, i.e., advertising and selling his product, and if the people who purchase this particular brand of cheese are not interested in learning the name of the cow who is the original source of the product, it might be rather difficult to stimulate their interest in finding out who made the glassware.

Aside from the question of glamorizing and publicizing the individual designer, another situation arises which will react unfavorably, i.e., overemphasis on the subject of design, especially as there is a tendency today to overemphasize or publicize ideas which are improbable or impractical. To be specific, the writer is alluding to the recent barrage of publicity emanating from both designers and manufacturers on the product of the future. If this is not guided along more practical lines, we are building ourselves up to a beautiful letdown.

Visions of the postwar world are flashed before the eyes of the consumer in bewildering array. Apparently he is being led to believe that once the war is ended, all he will have to do will be to wave a magic wand and see the all-plastic automobile or bathroom, kitchen, and prefabricated home materialize before his very eyes. As a designer, the writer appreciates the necessity for creative thinking and the value of visionary thinking, but unless it is tempered with common sense, it can create a dangerous situation. It is quite true that in the postwar period designers and manufacturers will have at their disposal many facilities and materials which heretofore were deemed either impossible or impractical, and it is also undoubtedly true that the advent of these new materials will enable us to do many things that we have been unable to accomplish in the past, but it will take several years of experimenting and trial before they are commercially practical and available to the public.

There are almost untold opportunities for the designers of this country to strengthen and build up their profession, and it certainly will not be too long hence when the artist or designer will find himself accepted as an integral part of industry, but to do this he must be his own severest critic and remember that, to be successful, a designer's ideas must help pay dividends.

ACTIVITIES OF THE SOCIETY

AMENDMENTS TO CONSTITUTION RELATIVE TO FELLOW ORGANIZATION

In accordance with a vote passed at the Annual Meeting of the Fellows of The Society on April 2, 1944 (see page 231, July, 1944, issue of *The Bulletin*), a mail ballot of the Fellowship on the proposal to discontinue its existing autonomous organization was taken with the following result:

In favor of discontinuance	132
Opposed to discontinuance	11
Recorded as not voting	2
Total	145
Total number of Fellows July 7, 1944	262

As instructed at the Annual Meeting, the Dean of Fellows, Robert B. Sosman, submitted the two following amendments to the Constitution which will put the decision into effect.

Article III. Membership

Section (1) (*c*) Delete all but the first sentence and add the following second and third sentences: "They shall be elected by the Board of Trustees in the manner provided in the By-Laws. Fellows shall be entitled to use the title "FELLOW OF THE AMERICAN CERAMIC SOCIETY" or the abbreviation "F.A.CER.S.," but shall have no powers, rights, or duties different from those common to Members, except as provided in the Constitution or By-Laws of THE SOCIETY."

Article IX. Fellows

Delete entire article.

In accordance with Article XV, these amendments were submitted to the Board of Trustees. The Board voted to submit these amendments to the members of The Society. They will be voted on at the next Annual Meeting April 16, 1945. If then approved, these amendments will again be published and then submitted by letter ballot to the members of The Society.

NORTHERN OHIO LOCAL SECTION ORGANIZED

A Northern Ohio Local Section has been organized in Cleveland, Ohio. It will serve the northeastern section of the State of Ohio and the approximately 150 members of The Society located in that area. A charter was presented at the initial meeting held October 10.

The Organizing Committee was composed of the following members:

E. M. SARRAF, Harbison-Walker Refractories Co., Cleveland, Ohio, *Chairman*.
E. E. CALLINAN, Timken Steel & Tube Co., Research Dept., Canton, Ohio.
J. E. HANSEN, Ferro Enamel Corp., Cleveland, Ohio.
G. E. REINKER, General Electric Co., Glass Technology Lab., Cleveland, Ohio.
S. M. SWAIN, North American Refractories Co., Cleveland, Ohio.

WHAT SHALL I TELL A PROSPECTIVE MEMBER?

1. Tell him that The American Ceramic Society is the largest organization in the world devoted to the technical phases of the conversion of earthen materials into useful products.

2. Tell him that 335 individuals and organizations in foreign countries think enough of American Ceramic Society technical publications to send to America for them, even arranging funds over the hurdles of restricted currency transactions.

3. Tell him that The American Ceramic Society is cooperating with other technical organizations to provide the necessary literature to re-establish the arts and sciences in devastated countries.

4. Tell him that The American Ceramic Society is recognized in foreign countries as well as in America.

Then ask him for his membership!

PAID MEMBERSHIP AND SUBSCRIPTION RECORD

Date of Record	Members Paid		Deferred	Subscriptions	Monthly Sales	Total Circulation
	Personal	Corporation				
September 21, 1943	2021	295	6	487	220	3029
January 21, 1944	2110	323	4	531	220	3188
February 21, 1944	2147	330	4	540	220	3241
March 21, 1944	1844	323	4	523	220	2914
August 21, 1944	2198	379	3	604	220	3404
September 21, 1944	2246	389	2	601	220	3458
12-month % gain	11.1	31.8		23.4		14.1

MEMBERS IN SERVICE*

The following members of this Society are in fighting units of war service. There are several in service in Washington not included in this Service Roster. This list, which was begun September, 1942, and added to each succeeding month, is probably not complete, and we would appreciate information on other members.

(342) ROBERT B. ADAIR, 215 10th Ave., Belmar, N. J.
(343) M. DOUGLAS BEALS, 33 Grove St., Perry, N. Y.
(344) LAWRENCE R. BICKFORD, JR., Pennsylvania State College, State College, Pa.
(345) F. L. BURNS, Roseville Pottery, Inc., Zanesville, Ohio.
(346) AARON COHEN, University of Saskatchewan, Saskatoon, Saskatchewan, Canada.
(347) JOHN E. CORDES, Globe Union, Inc., Milwaukee, Wis.
(348) FRANK L. CORNISH, N. Y. State College of Ceramics, Alfred, N. Y.
(349) GEORGE CORNWELL, N. Y. State College of Ceramics, Alfred, N. Y.
(350) A. B. COSBY, Owens-Illinois Glass Co., Huntington, W. Va.
(351) JAMES CROOKSTON, A C Spark Plug Co., Flint, Mich.
(352) DANIEL W. DEWOLF, Corning Glass Works, Corning, N. Y.
(353) JOHN W. GARRISON, General Electric Co., Cleveland, Ohio.
(354) LAWRENCE P. GARVEY, N. Y. State College of Ceramics, Alfred, N. Y.
(355) LT. (j.g.) FRED L. GOIN, U.S.N.R., Fleet Postmaster, New York, N. Y.
(356) ALLAN S. HALPERN, Rutgers University, New Brunswick, N. J.
(357) DONALD W. HAMER, University of Illinois, Urbana, Ill.
(358) HARRY E. LUTHER, Stockton Fire Brick Co., Pittsburg, Calif.
(359) GRANT E. MILLER, Ohio State University, Columbus 10, Ohio.
(360) VERNON W. MOSS, Johns-Manville Products Corp., Lompoc, Calif.
(361) HOWARD E. PETTY, Harbison-Walker Refractories Co., Pittsburgh, Pa.
(362) LEO POZEFSKY, N. Y. State College of Ceramics, Alfred, N. Y.
(363) K. WARREN ROLLINS, American Porcelain Enamel Co., Muskegon, Mich.
(364) FRANK A. RUGH, JR., Pennsylvania State College, State College, Pa.
(365) S. LEWIS SANTOMIERI, U. S. Maritime Commission, Washington, D. C.
(366) WILLIAM J. SCHARFENAKER, Carnegie-Illinois Steel Corp., Chicago, Ill.
(367) WILLIAM A. SCHOLES, 18930 Littlefield Ave., Detroit, Mich.
(368) HORACE K. SHOENBERGER, Carborundum Co., Niagara Falls, N. Y.
(369) WILLIAM D. SMILEY, Pennsylvania State College, State College, Pa.
(370) F. EDWARD SNYDER, Pennsylvania State College, State College, Pa.
(371) IRA A. STARK, 1118 South 2d St., Louisville 3, Ky.
(372) E. E. STOTT, Georgia School of Technology, Atlanta, Ga.
(373) EDWIN R. TODD, Ceramic Dept., Carnegie-Illinois Steel Corp., Chicago, Ill.
(374) JACK H. VEALE, General Refractories Co., Baltimore, Md.
(375) INO WEISKE, Georgia School of Technology, Atlanta, Ga.
(376) JAMES F. WYGANT, University of Alabama, University, Ala.

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* These are in addition to the lists published monthly, beginning with the September, 1942, *Bulletin*, with the exception of the June, 1943, issue.

NEW MEMBERS IN SEPTEMBER

Corporation

AMERICAN OPTICAL CO., E. D. Tillyer (voter), Southbridge, Mass.
AUSTENAL LABORATORIES, INC., Paul F. Collins (voter), 5932 Wentworth Ave., Chicago, Ill.
BARTLETT-COLLINS CO., D. C. Hamilton (voter), Sapulpa, Okla.
CRUNDEN MARTIN MFG. CO., E. A. Schwarz (voter), 760 S. Second St., St. Louis 2, Mo.
EASTMAN KODAK CO., Research Library, Kodak Park Works, Rochester 4, N. Y.
EMSCO REFRACTORIES CO., H. B. Blessing (voter), 8601 Dorothy Ave., South Gate, Calif.
EVANS LEAD CO., R. M. Evans (voter), Box 1467, Charleston 25, W. Va.
JOHNSON GLASS CO., William Garland (voter), 5248 Elston Ave., Chicago 30, Ill.
LATCHFORD-MARBLE GLASS CO., Baird Marble (voter), 7507 Roseberry Ave., Los Angeles, Calif.
METALLOY CORPORATION, Walter M. Fenton (voter), 1320 Rand Tower, Minneapolis, Minn.
WESTERN FELDSPAR MILLING CO., J. W. Magnuson (voter), 1333 W. Maple St., Denver, Colo.

Personal

BUTLER, WILLIAM F., 3443 Valley Green Dr., Drexel Hill, Pa.; Spencer Lens Co.
CHERNIAKOV, SEMEON S., 1851 Columbia Rd., N. W., Washington, D. C.; ceramic engineer, Soviet Purchasing Commission.
FISCHER, KERMIT, R. D. 1, Doylestown, Pa.; Fischer & Porter Co.
FOOTE, PAUL C., 5036 Drexel Blvd., Chicago 15, Ill.; chief optical engineer, Bell & Howell Co.
HOGENDOBLER, H. R., Owens-Corning Fiberglas Corp., Toledo 1, Ohio.
HOYET, EUGENE, Box 213, Natrona Heights, Pa.; Pittsburgh Plate Glass Co.
INGLE, HENRY W., 35 Giddings Ave., Windsor, Conn.; container engineer, Hartford-Empire Co.
KIDWELL, J. F., 4026 Beechwood Blvd., Pittsburgh, Pa.; manufacturing engineer.
KYLE, H. CLINTON, 34 Radium St., Pittsburgh, Pa.; Forter-Teichmann Co.
LONG, LUTHER L., Owens-Corning Fiberglas Corp., Newark, Ohio.
MCINTOSH, HAROLD W., Hartford-Empire Co., Hartford, Conn.

* McLAUGHLIN, N. H., Alsey Brick & Tile Co., Alsey, Ill.; president.
McMASTER, HAROLD A., 619 Toronto St., Toledo 9, Ohio; Libbey-Owens-Ford Glass Co.
McNEIL, KENNETH D., 83 W. Third St., Corning, N. Y.; Corning Glass Works.
* NEWTON, R. L., Owens-Illinois Glass Co., Bridgeton, N. J.
RESEK, STEPHEN, 1064 Woodbury Rd., New Kensington, Pa.
* SANTMYERS, GEORGE S., 812 Washington Dr., Bellevue Branch, Pittsburgh 2, Pa.; Mellon Institute.
SMITH, EDWIN G., 441 Old Farm Rd., Mt. Lebanon, Pa.; Amsler-Morton Co.
SMITH, LELAND, Acme Brick Co., Box 708, Denton, Texas; ceramic engineer.
STICKLEY, E., Pittsburgh Plate Glass Co., Creighton, Pa.
TIMS, JOHN W., 63 Moull St., Newark, Ohio; Owens-Corning Fiberglas Corp.
WELSHANS, LEWIS T., 404 Mentor Ave., Painesville, Ohio; Diamond Alkali Co.
WHITELEGGE, J. G., 4 Pennell St., Clayton, Manchester 11, England.
WYCKOFF, LEWIS B., Electro Metallurgical Co., Niagara Falls, N. Y.
YOUNG, WILLIAM O., 1796 Tonawanda Ave., Akron 5, Ohio; Colonial Insulator Co.
ZAPUN, C. G., 43-00 Thirty-Sixth St., Long Island City, N. Y.; manager, Zapun Ceramics.

Student

Rutgers University: SIDNEY E. LASTER.
University of Washington: ELOISE M. McKINNELL.

* Indicates former member of The Society rejoining.

MEMBERSHIP WORKERS' RECORD

CORPORATION: Richard Brian 1, Clare Chaffee 1, E. W. Emrich 1, L. C. Hewitt 1, F. A. Petersen 1, A. G. Pincus 1, F. V. Tooley 1, Office 4.

PERSONAL: G. D. Brush and C. M. Harder 1, R. A. Buchholz 1, A. H. Couch 1, L. P. Forman 1, S. A. Forter and K. G. Kutchka 1, W. S. Glover 1, J. S. Gregorius 1, Frederick Heath, Jr., and F. V. Tooley 1, L. C. Hewitt 2, A. K. Lyle 2, P. M. Offill 1, Ralston Russell, Jr. 1, E. M. Sarraf 1, H. E. Simpson 1, E. W. Tillotson 1, F. V. Tooley 2, D. E. Walsh 1, R. W. Wilson 1, Office 5.

STUDENT: K. E. Denny 1, E. P. McNamara 1.

GRAND TOTAL: 39.

NECROLOGY

WILLIAM G. GRIFFITHS

William G. Griffiths, president of the Pyro Clay Products Co., Oak Hill, Ohio, died suddenly of a heart attack July 28, 1944. Mr. Griffiths was one of the most outstanding and well-liked businessmen in his community, and his sudden death came as a great shock to his many friends and acquaintances.

He was born in Cincinnati, Ohio, October 14, 1870. He paid his way through a college of law by working as a commercial telegraph operator. In 1909, learning of the clay deposits in the south central section of Ohio, he went there to investigate and later interested Cincinnati capital in erecting what is now known as the Pyro Clay Products Company. He was made secretary of the Company.

A fire destroyed the plant in 1931, at a time when the depression was at its height. Most of the stockholders gave up in disgust, but Mr. Griffiths went forward and established another company, of which he became president and principal stockholder. By clever management and by turning out first-class products, Mr. Griffiths established a reputation as a brick manufacturer and kept his plant operating while the others had to shut down. Twice the Company has received the Army-Navy Award.

At the time of his death, Mr. Griffiths was district chairman of the American Refractories Institute and a member of the veterans' Board of Appeals of the Jackson district. At one time he served as chairman of the Republican Executive Committee and as an elector when Herbert Hoover was a candidate for his second term. He was also a member of the Masonic fraternity and the Congregational church of Cincinnati.

FRANK H. REAGAN

Frank H. Reagan, chairman of the Board of the Locke Insulator Corp., Baltimore, Md., died suddenly September 10, 1944, at the age of sventy-one.

Mr. Reagan was probably the best-known figure in the insulator industry. He joined the Locke Insulator Corporation in 1917 as vice-president and general manager and was successively president and, for the past four years, chairman of the Board of that organization.

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444 Lake Shore Drive, Chicago, Illinois 550 South Flower Street, Los Angeles, Cal.

CHARLES A. FREEMAN OF A. P. GREEN FIRE BRICK CO. ACCEPTS CHAIRMANSHIP OF PROGRAM COMMITTEE, REFRACTORIES DIVISION

Because of the pressure of new work and because he will be practically out of refractories work, E. B. Read has resigned as chairman of the Program Committee.

NOTES FOR CERAMISTS

JOHN GOODWIN

Story of Pioneer Potter

In the November, 1942, issue of *The Bulletin*, the feature historical story was of John Goodwin, written by Lucille T. Cox. On her feature stories Mrs. Cox is a painstaking research worker, and in this instance she relied on family records and legendary stories passed down through the generations of Goodwins. Those of the Goodwin descendants who read Mrs. Cox's story confirmed the story as being factual.

Legendary stories surely do get twisted far from the facts even in a short space of time, as each one knows from personal experience. No wonder that through a century history stories of John Goodwin as passed on by the descendants became warped.

The only legendary Goodwin story that is not in line with the facts is that "During the opening years of the nineteenth century, England was faced with the problem of too many people. Her industrial towns were crowded centers of a teeming population living in filthy disease-ridden quarters. Compulsory emigration became the order of the day.

"The potters in Burslem were each given a number. At stated times, drawings were made, and the men possessing the called numbers were required to leave England in a fortnight or face life imprisonment. They could go to one of the English colonies or, by special permission, to America. John Goodwin's number was selected in January, 1842. He had no choice but to sell his belongings, poor and meager as they were, send his wife and young daughter to his wife's parents, and leave England."

The Goodwin story as presented by Mrs. Cox, based on family records, goes on to relate that in the spring of the following year (1843) John Goodwin had established a factory and had saved enough money to send for his wife and daughter. This he is said to have accomplished in a period of not more than eighteen months, and concerning this there is no doubt.

Mrs. Cox's attention was called by Dr. Andrew Dingwall to the probable inaccuracy of the statement that John Goodwin had been compelled to leave England. As the result of his communications with the British Information Services, the two following letters were received, and it is out of respect to the recorded excellent achievements and character of John Goodwin that they are now published:

Letter No. 1

In reply to your inquiry about compulsory emigration from England in the 19th Century, we are unable to find any evidence that there was such emigration. The Parliamentary Statistics of the period contain no provisions for enforced emigration.

The phenomenal growth of the population at the beginning of the 19th Century, together with the severe economic depression after the Napoleonic wars, were the chief causes which promoted emigration from Great Britain at that time. In 1817, a Select Committee on Poor Law had recommended "that all obstacles to seeking employment wherever it can be found, even out of the realm, should be removed, and every facility that is reasonable afforded to those who *may wish* to resort to some of our colonies." From then on the outflow to North America and the Colonies grew annually, and Parliament voted large sums of money for the assistance of those seeking to leave.

Emigration was at that time painted in such glowing terms, that far from being compulsory, it became the poor man's dream—to leave behind him the acute economic distress at home and try his fortune in the New World. The chief difficulty was to provide sufficient funds for all those who wished to go.

Among other sources of assistance, various trade unions started emigration funds, and "The Potters Joint Stock and Emigration Co." at Burslem was the first to do so. It had for its object the purchase of 12,000 acres of land in the Western States which it proposed to sell in small lots to members at cost prices, repayments being made by installments spread over the years. People within the Staffordshire district paid a fee of sixpence weekly and became members emigrating in due course. Apparently John Goodwin was among them.

A system of numbers may very likely have been used to determine which members should be the first to leave, but any suggestion that departure was compulsory seems to be completely without foundation.

(signed) J. A. W. BENNETT,
Information Division,
British Information Services,
30 Rockefeller Plaza,
New York, N. Y.

Letter No. 2

Whilst I was in England last month I discussed with several historians the story about John Goodwin which you drew to my attention some time ago, and we have since received a reply from the Home Office substantiating the view which everyone whom I consulted took, namely, that "In 1842, when John Goodwin is said to have drawn an unlucky number, the only system of compulsory emigration was that provided by the various Transportation Acts. These provided that for many specified offenses a person could be sentenced or ordered to be transported to some place out of the United Kingdom. It was essential, however, that in every case there should be a conviction of an offense by a competent court." But, of course, transportation to America had ceased with the American War of Independence in 1776, so the possibility of that sort of compulsory emigration does not arise in John Goodwin's case. One is justified, therefore, in making a complete denial of the suggestion that John Goodwin was forced to emigrate, and if necessary you may quote the Home Office as your authority. (signed) J. A. W. BENNETT

DR. KREIDL TO CELEBRATE SEVENTY-FIFTH BIRTHDAY IN DECEMBER

Ignaz Kreidl, founder of the Kreidl Chemico-Physical Corp., New York, N. Y., will celebrate his seventy-fifth birthday December 11, 1944.

To Dr. Kreidl we extend our most sincere best wishes and our hope that he will continue to be active in his chosen field for a long time to come.

Biography

Dr. Kreidl was born in 1869 in Gratzen, Czechoslovakia, which then was Austria. He obtained the Ph.D. degree from the University of Vienna in 1892, where he remained for some time as the private assistant of Professor Von Lieben, head of the Department of Chemistry. In the late nineties, he joined the Welsbach Company as a research chemist. When he left this Company in 1908, he was research manager and co-manager of production of the

Austrian plant and consultant for the other European Welsbach factories.

As the Welsbach Company was engaged in the manufacture of gas mantles as well as the development of materials used in their manufacture, Dr. Kreidl became one of the early experts in the new field of rare earths and related ceramic materials. In 1908, he founded a chemical factory originally concerned with the development and manufacture of rare-earth products and later expanding into other ceramic and chemical processes originating in his research laboratory.

His researches in ceramics led to the development of the opacification of enamels and glazes with zirconia and the preparation of suitable forms of zirconia by means of small controlled alkali additions; the opacification with gas bubbles; the introduction of silicofluorides to enamel frit opacifiers and the manufacture of various fluorides and synthetic cryolite for the ceramic industries; and the development of alloyed steels of special adherence properties. In the field of plastics, he introduced the concept of plastophore groups and organized and built factories engaged in the production of phenolic and urea resins according to new patented processes, particularly in the field of insulating and highly transparent materials. In the field of agricultural chemistry, he also originated and manufactured various products including insecticides, fungicides, and bactericides. His industrial activities embraced the organic fields also, the manufacture of saccharine being the most important.

As a principal shareholder and executive of various European glass factories, he became deeply interested in problems of glass research, manufacture, and trade. The extensive laboratories, the library, and the various factories of the organization thus created fell victim to the invasion of Central Europe exactly thirty years after their foundation. In his seventieth year, Dr. Kreidl came to the United States, where two of his sons, N. J. and E. L. Kreidl, already were engaged in ceramic research. Here he started the research laboratory, the Kreidl Chemico-Physical Corporation, where together with his son Werner he has continued his researches and the development of his patent holdings, partly in cooperation with other chemical and ceramic industries.

After a life of changing fortunes, Dr. Kreidl is still active in ceramic and chemical enterprise, probably one of the members of The Society with the longest continuous record of such activities.

Patents

Dr. Kreidl has been granted more than two hundred patents, twenty-one of which have been issued in the United States; six pertain to plastics, three to the photochemical process, one to enameled ware, and eleven to the opacification of porcelain enamels. The latter group of patents is listed as follows:

(1) "Opacifying Enamels," U. S. 1,849,192, March 15, 1932.
(2) "Production of Opaque Glasses and Enamels," U. S. 1,948,461, Feb. 20, 1934.
(3) "Clouded Vitreous Enamel," U. S. 2,102,630, Dec. 21, 1937.
(4) "White Clouded Vitreous Enamel," U. S. 2,103,228, Dec. 21, 1937.
(5) "Making White Clouded Iron Enamel," U. S. 2,103,229, Dec. 21, 1937.
(6) "White Clouded Vitreous Enamel," U. S. 2,118,047, May 24, 1938.
(7) "Opaque Vitreous Enamel and Process of Making," U. S. 2,147,202, Feb. 14, 1939.
(8) "White Opaque Vitreous Enamel Frit," U. S. 2,165,554, July 11, 1939.
(9) "Producing Enamel, More Particularly White Clouded Enamel," U. S. 2,236,852, April 1, 1941.
(10) "Making White Clouded Enamel," U. S. 2,267,928, Dec. 30, 1941.
(11) "Making White Clouded Enamel," U. S. 2,305,313, Dec. 15, 1942.

CERAMICS AT UNIVERSITY OF ILLINOIS

The Department of Ceramic Engineering at the University of Illinois is continuing to offer complete undergraduate and graduate curricula. Freshman students and all graduate students registered for the fall semester October 7 to 10, and the sophomore, junior, and senior students will register November 2. The difference in the registration periods for the freshmen and upper classmen is due to the fact that the Engineering College has synchronized the upper classmen's program with that of the Navy V-12 program.

The number of foreign students enrolling in the Department of Ceramic Engineering is continuing to increase. Our foreign enrollment is as follows: undergraduates, Haraldur Asgeirsson, Iceland, and Jorge Guardia, Republic of Panama; graduates. Pociano Montemayor, Monterrey, Mexico, and Wen Te Yu, China.

Extensive changes have been made in the general layout of the Kiln House. The equipment pertaining to the various branches of ceramics has been grouped individually. The laboratory Vac-Aire deairing machine and the Simpson mixer have been placed in the Kiln House. A special kiln, which is capable of reaching cone 30, has been constructed for increased study in the high-temperature range. Two smaller kilns have been designed for more careful study of glaze and body trial burns. The number of smelting furnaces has been increased and regrouped. A new Hoskins electric furnace with complete control equipment has been installed. An additional laboratory rotary smelter has been ordered for the Kiln House.

Additional equipment has been obtained for other laboratories. A Globar furnace has been installed for a more complete study of bodies and glasses, a new viscosity apparatus for determining viscosities of glasses has been constructed, and a Taber surface abraser has been obtained for a more complete study of various ceramic surfaces.

A heavy program of cooperative research work is being continued in the Department of Ceramic Engineering. The two Government research investigations, one sponsored by the Army Air Forces and the other by the National Research Defense Council, are also being continued.

—R. L. Cook

NATIONWIDE ASSOCIATION OF ENGINEERS FAVORED

A nationwide association of engineers, embracing all branches of that profession, was advocated recently by C. A. Powel, newly elected president of the American Institure of Electrical Engineers and international authority on power-plant problems.

Speaking before the Los Angeles Section meeting of the A.I.E.E., Mr. Powel declared that "in a world where scientific knowledge and engineering achievement are shaping our habits of thought and life, there is urgent need for an all-inclusive organization that can speak for engineers in the councils of government and the ranks of industry."

Mr. Powel, who is manager of Headquarters Engineering of the Westinghouse Electric and Manufacturing Company, said that such an organization must have "constant and intimate contact with the rank and file of engineers and must bring its weight to bear in community and civic affairs."

Collective Action Necessary

"The desire for collective action," Mr. Powel stated, "is as powerful among engineers as it is among members of labor or 'white-collar' unions. What form that collective action should take is the main question facing members of the profession today."

Two plans of joint action have already been tried. The first, put into effect by the American Society of Civil Engineers, authorizes local sections of the A.S.C.E. to set themselves up as collective bargaining units. The second plan favors the inclusion of engineers in the general "white-collar unions."

"Both of these plans offer serious difficulties," Mr. Powel asserted. "The first would probably mean the elimination of supervisory workers from the bargaining units and in addition presents a number of legal obstacles. The second plan, while attractive in some respects, has several disadvantages.

"In any concern, no matter what size, the ratio of engineers to draftsmen, clerks, accountants, and others is almost of necessity small. In addition, the engineer would be subjected to decisions and rules which are clearly intended for a great majority of men doing an entirely different class of work."

He disclosed that the A.I.E.E. had formed a joint committee with the American Society of Mechanical Engineers to investigate the subject of collective bargaining units for local Society sections and added that "their preliminary study has brought out the tremendous difficulties of such a plan."

Engineer Likely to Be Individualist

Mr. Powel declared that by the very nature of his work the engineer "has something different to sell than the machinist, the clerk, or the laborer."

"The engineer's training has developed his creative instinct. His work is not adapted to control by any ordinary time-study procedure nor can his hours of work be put on a rigid schedule. He is much more likely to become an individualist than a man working with a group in the shop. Nevertheless, he has the same desire to seek protection in collective action.

"It is doubtful, however, if a bargaining agency in the ordinary sense of the term is necessary or desirable for engineers. The protection he rightly seeks could probably be provided more effectively by an overriding association embracing all engineers devoted specifically to the welfare of the profession as a whole and the individual members comprising it."

W. F. DIETRICH ORGANIZES CONSULTING MINING AND METALLURGICAL COMPANY

Waldemar F. Dietrich, consulting mining and metallurgical engineer, and G. H. Morse, research and analytical chemist, have organized the company of Dietrich, Morse and Associates to conduct investigative and research projects in the mineral and chemical industries, with special emphasis on the development of western enterprises.

The main offices and laboratories of the Company are located at 316 Sixteenth St., Sacramento 14, Calif., and a southern California office has been opened at 512 Baughman St., Claremont, Calif.

Mr. Dietrich, a member of The American Ceramic Society for the past eighteen years, has been engaged most recently as consulting mining engineer and geologist for Gladding, McBean & Co., Los Angeles, Calif. Last autumn he acted as ceramic consultant for the H. J. Kaiser Company in the Development and Engineering Division, and the first part of this year he was chief research engineer for Kaiser Company, Inc.

Mr. Dietrich has contributed extensively to the literature in his field, his publications of interest to ceramists being as follows:

(1) "Clay Resources and the Ceramic Industry of California," *Calif. Div. of Mines and Mining Bull.*, No. 99 (Jan., 1928).

(2) "Clay Prospecting and Mining in California," *Trans. Amer. Inst. Mining Met. Engrs.*, **76,** 413–29 (1928).

(3) (With D. R. Irving) "Some Aspects of Plasticity and Related Properties of Clays," *Jour. Amer. Ceram. Soc.*, **12** [1] 14–29 (1929).

(4) (With W. W. Meyer) "Investigation of Possible Use of Certain California Clays in Vitreous China Sanitary-Ware Bodies," *ibid.*, **13** [3] 202–17 (1930).

(5) "Clay Deposits of California," *Bull. Amer. Ceram. Soc.*, **19** [9] 340–44 (1940).

CHAMPION SPARK PLUG COMPANY RECEIVES ARMY-NAVY AWARD

The Champion Spark Plug Co., Ceramic Division, Detroit, Mich., has received the Army-Navy Production Award for Excellence in War Production. The Award was made to the Company, a Corporation Member of The American Ceramic Society, August 29, 1944.

INSTRUMENT COURSE REOPENED BY BROWN

The first of the 1944–1945 industrial instrument maintenance and repair courses of the training school of the Brown Instrument Company, the Philadelphia division of the Minneapolis-Honeywell Regulator Company, started September 25. The classes are being attended to the largest extent by personnel from customer plants. The course will continue until and including December 22.

Classes from September 25 to October 16 studied millivoltmeter-type pyrometers. Mechanical potentiometer pyrometer studies and lectures will be held from October 17 to November 1. Continuous-balance electronic potentiometer classes will be held from November 2 to November 9. Other studies and the periods in which each will be covered are electric-operated automatic control, November 10 to 20; flowmeters, November 21 to 30; thermometers, pressure gauges, and hygrometers, December 1 to 8; air-operated automatic control, December 11 to 13; and CO_2, analygraph, resistance thermometers, and tachometers for the remainder of the period in the order named.

During the summer, the Brown school taught representatives of the military of this and allied nations. It also had a large number of students who had been honorably discharged from the Army and Navy.

FERRO ENAMEL TO BUILD NEW WEST COAST PLANT

Plans for a new manufacturing plant, to be located in the Los Angeles area, have been announced by Robert A. Weaver, president of the Ferro Enamel Corp., Cleveland, Ohio.

The new plant will produce porcelain enamel frit and synthetic-enamel industrial paints. In addition, the complete line of other Ferro products, such as clays, oxides, chemicals, driers, and various supplies, will be warehoused at the new plant and distributed throughout the western states and foreign countries bordering on the Pacific.

Ferro's engineering service in the porcelain enameling and other ceramic fields will also be available through this new organization.

This plant is the ninth frit-smelting plant to be put into operation by Ferro.

SIMPLIFIED PRACTICE RECOMMENDATION R61–30, CLAY TILE FOR FLOORS AND WALLS

A revision of Simplified Practice Recommendation R61–30, Clay Tile for Floors and Walls, has been approved for promulgation, according to an announcement received from the Division of Simplified Practice, National Bureau of Standards. Effective September 1, 1944, it was identified as R61–44.

The recommendation is now broadened to include wall-tile trimmers, flat quarry tile, quarry-tile trimmers, and quarry-tile colors, in addition to glazed wall tile and ceramic mosaic. The glazed wall-tile sizes remain the same as in the superseded issue, but in the ceramic mosaic there are a number of additional sizes and shapes listed. In the categories which are new to the recommendation with this issue, a considerable reduction is noted in the number of stock sizes and shapes commonly manufactured.

Until printed copies are available, a limited number of

mimeographed copies of the recommendation may be obtained from the Division of Simplified Practice, National Bureau of Standards, Washington 25, D. C.

DOW CORNING ANNOUNCES COMMERCIAL AVAILABILITY OF SILICONES

The first commercial production of Silicones, new organosilicon polymers, has been announced by the Dow Corning Corp., Midland, Mich. The development of silicones on a semiproduction basis has been in progress for some time. Several of these products are now being made available by Dow Corning for applications essential to the war effort. Dow Corning products include water-white fluids for high- and low-temperature use, electrical varnishes and insulating resins for high-temperature-operating electrical equipment, and lubricating greases for high-temperature and chemical-resistant uses. These products, because of their unusual properties, have solved many problems where conventional materials have failed. Little factual information has been available on organosilicon products, although their possibilities have been the subject of recent short articles in the press.

The Dow Corning Corporation was formed in February, 1943, by the Corning Glass Works and The Dow Chemical Company to manufacture and develop silicones more intensively. The Corning Glass Works had been conducting research in organic derivatives of silicon for more than a decade. It is interesting to note that this early work was initiated by their research workers because of the advent of glasslike plastics. As glass is a silicon product, it was believed possible by them that organic derivatives of silicon should yield products having some unusual and valuable properties, perhaps similar in some degree to those of glass.

As so frequently occurs, the research of the Corning scientists led down unforeseen paths. In the course of their investigations water-white liquid polymeric silicones were discovered with unusual chemical and physical properties. These materials, which are interesting from an engineering standpoint, are now available under the name of Dow Corning Fluids. They are manufactured in various viscosities ranging from liquids as thin as water to those which barely flow at room temperature. Their most outstanding property is an exceptionally low rate of viscosity change with temperature, compared with that of previously used liquids. Certain types are made that do not freeze at dry-ice temperatures and these same products can be used at temperatures up to 400° to 500°F.

The exact purposes for which these materials have been developed cannot be disclosed at this time. They are now in quantity production however, and samples together with detailed information on their properties can be obtained from the manufacturer.

Among the other products that stemmed from Corning research are electrical insulating varnishes and resins now available from the Dow Corning Corporation. These materials are the culmination of early efforts by Corning research workers to find suitable coating resins for use with glass textiles for electrical insulation or for other purposes where elevated temperatures are apt to be encountered. In general, none of the organic varnishes was substantially better, from the standpoint of heat resistance, than the cotton or paper usually used in electrical windings. Hence there was a definite need for resinous dielectrics that would not decompose and carbonize when electrical equipment was overheated.

Dow Corning silicone resins for electrical insulation extend the range of operating temperatures possible in electrical equipment beyond the limit of thermal stability of conventional organic materials. One of the resins is available as a coating and impregnating varnish which may be applied to Fiberglas cloth, asbestos cloth, asbestos paper, and Fiberglas-served wire, etc., by conventional dipping and drying methods. It requires baking at a temperature of 250°C. for one to three hours to cure to a nontacky state. Another is an impregnating varnish which sets with heat at 200°C. These materials do not carbonize or darken when subjected to prolonged heating at the curing temperatures. In combination with Fiberglas, asbestos, and mica, these Dow Corning impregnating and coating resins permit the design of many types of electrical equipment for higher safe operating temperatures with consequent increase in capacity, reliability, and life performance.

The Dow Corning Corporation has completed the construction of a commercial plant at Midland, Mich. Its new laboratory and office also are completed and in use. Dow Corning officials state that additional organosilicon products may be expected and will be announced as soon as they become available commercially.

AMERICAN SOCIETY FOR TESTING MATERIALS RECIPIENT OF ORDNANCE DISTINGUISHED SERVICE AWARD

The American Society for Testing Materials received word August 1 from Major General L. H. Campbell, Jr., Chief of Ordnance, U. S. War Department, that it had been awarded the Ordnance Distinguished Service Award in recognition of outstanding contributions made to Ordnance progress in the war.

General Campbell wrote in part as follows:

"It is my pleasure as Chief of Ordnance of the Army to tell you on behalf of the Ordnance Department that I am most grateful for the outstanding contributions the American Society for Testing Materials has made to Ordnance progress in this war. The degree of that progress is best shown by the success of our fighting forces in all theaters of operations.

"To attest the appreciation of the Department for the splendid services of your Society, I wish to present to the Society the Ordnance Distinguished Service Award. It is a diploma bearing the traditional seal of the Department and is awarded in recognition of scientific and engineering achievement."

This diploma was presented by Major General G. M. Barnes, Chief of Research and Development Service, at a special meeting of the Society held October 12 at Franklin Institute, Philadelphia, Pa.

EASTERN ENAMELERS' CLUB FALL MEETING

The fall meeting of the Eastern Enamelers' Club was held September 30, 1944, at the Lord Baltimore Hotel, Baltimore, Md.

The following program was presented:

(1) "Application of Low pH Cleaning to Porcelain Enamel" by R. F. LEWIS, Northwest Chemical Co., Detroit, Mich.

(2) "Electrostatic Spraying" by CAPTAIN J. B. WILLIS, member, Laboratory Staff, Pemco Corp., Baltimore, Md.

(3) "Architectural Porcelain Enamels" by HOWARD MICHAELS.

(4) "Widening Horizons for Porcelain Enamels" by EDWARD MACKASEK, Managing Director, Porcelain Enamel Institute, Washington, D. C.

JOHN R. HOSTETTER EXECUTIVE OF GLASS DIVISION, ZENITH OPTICAL COMPANY

John R. Hostetter, Chief of the Glass Unit, Chemicals Bureau, War Production Board, Washington, D. C., has resigned to accept a position as executive of the Glass Division of the Zenith Optical Co., Huntington, W. Va. He took up his duties September 25, 1944. This Company specializes in the production of radar, radio, and other scientific glassware. Mr. Hostetter will be in charge of glass manufacture.

He has been chief of the WPB Glass Unit since its incorporation in April, 1942. As its chief, Mr. Hostetter had complete control of raw materials, production, and distribution of window and plate glass, scientific, illuminating, and industrial glassware, and tumblers, table, kitchen, and ornamental glassware, a business amounting to approximately $300,000,000. Much of the highly specialized war-

useful glassware, lens and radar tubes, was developed under his guidance.

Immediately before his connection with WPB, he was assistant editor of *Glass Industry*. His former experience has been with the Corning Glass Works, Corning, N. Y. While attending Bucknell College, Mr. Hostetter, a member of The American Ceramic Society, specialized in ceramics and engineering.

Thomas H. Tremearne has been appointed Acting Chief of the Glass Unit, Chemicals Bureau, WPB. He formerly was with the Agriculture Chemical Section of the Chemicals Bureau and before that was employed by the Department of Agriculture, Washington, D. C.

AMERICAN SOCIETY OF MECHANICAL ENGINEERS 1944 AND 1945 MEETINGS

1944 Annual Meeting, Hotel Pennsylvania, New York, N. Y., November 27 to December 1.

1945 Spring Meeting, Hotel Statler, Boston, Mass., April 16, 17, and 18.

1945 Semiannual Meeting, Hotel Stevens, Chicago, Ill., June 18, 19, and 20.

AMERICAN CHEMICAL SOCIETY

109th Annual Meeting, Chicago, Ill., September 10 to 14, 1945.

MORE ABOUT CERAMIC MINE PRODUCTION*

The Onondaga Pottery Company developed and carried on all of the preliminary tests of the present nonmetallic mine. As a result of these preliminary tests, the item was standardized for limited procurement to ascertain how feasible this item could be made in mass production. In this initial production of the mine and fuse, the following organizations were involved:

Onondaga Pottery Co., Syracuse, N. Y., manufacture of ceramic parts for and assembly of mines.

Ohio Brass Co., Barberton, Ohio, manufacture of ceramic parts for and assembly of mines.

Owens-Illinois Glass Co., Muncie, Ind., manufacture of glass parts for and assembly of mines.

These three companies developed practical manufacturing procedures and the nonmetallic mine was then put into general procurement in large quantities. As a result of this general procurement, the following additional organizations in the ceramic industry began to manufacture or assemble parts. These were in addition to continued production of the original three companies.

Shenango Pottery Co., New Castle, Pa., which manufactured ceramic parts and assembled the mines.

American Radiator & Standard Sanitary Corp., Trenton, N. J., which manufactured ceramic parts only.

Porcelain Products, Inc., Parkersburg, W. Va., which manufactured ceramic parts only.

Coors Manufacturing Co., Golden, Colo., which also manufactured ceramic parts only.

Illinois Electric Porcelain Co., Ravenna, Ohio, which made ceramic parts.

The only ceramic organization which has been making fuses and still is making them is Pass & Seymour, Inc.

* See *Bull. Amer. Ceram. Soc.*, **23** [9] 331 (1944) for initial story.

BOOKLET ON O. HOMMEL COMPANY WAR EFFORT

The O. Hommel Company has released a booklet which tells the story of their participation in the all-out production drive on the home front. A series of war combat photographs dramatically illustrates how the Hommel product, powdered magnesia, has been used for flares, tracers, smoke, and incendiaries.

The booklet, attractively printed in blue and black with loose-leaf binding, may be obtained by writing on company stationery to the O. Hommel Co., 209 Fourth Ave., Pittsburgh, Pa.

HANDBOOK OF DESCRIPTIONS OF SPECIALIZED FIELDS IN CERAMIC ENGINEERING AND TECHNOLOGY

Prepared by the National Roster of Scientific and Specialized Personnel, Bureau of Placement, War Manpower Commission

INTRODUCTION

I. What It Is

This handbook of descriptions of the specialized fields of work in ceramic technology and ceramic engineering is one of a series being prepared by the National Roster of Scientific and Specialized Personnel. This volume contains the descriptions of the usual or typical activities of technical personnel working in each of the fields of specialization in ceramics.

The general classification scheme used in this description is a modification of that originally developed by the National Roster during 1940 and 1941, in collaboration with the national professional and technical societies. The classification is primarily on a commodity or industry basis, since most ceramic technologists and engineers are characteristically specialized along such lines.

The term "fields of specialization" as used in this handbook connotes a well-defined occupational area within the profession. It is the particular type of work performed by a substantial number of ceramic technologists or engineers. The work of those classified in the specialty has a number of readily recognizable common elements. These elements include the basic technical knowledge and skills, the particular raw materials dealt with, and reactions, processes, equipment, and operations employed in obtaining the final product or results. The various positions which would be classified in this specialty have so many of these elements in common that there is a high degree of transferability among them.

Most of the descriptions follow a pattern which permits an orderly presentation of the specialist's work.

Each field of specialization is now described in detail. The discussion is typically on the basis of raw materials, processes, equipment, or techniques peculiar to the specialty, and the end product or results attained. The discussion is usually subdivided into several sections devoted to each of the major functional activities, since it is well recognized that the work of a man engaged in research will differ materially from work in production in connection with a given commodity. Little if any attempt is made to define technical terms, since to do so would result in a work of encyclopedic proportions.

Allied fields are also discussed. The relationships of this branch to other fields of science are pointed out.

An index (not included herein) lists all important raw materials, end products, techniques, processes, reactions, and equipment discussed in this handbook. Thus, the reader can readily determine all of the specialties which deal with a particular process or product.

II. How It Was Prepared

In most instances the original draft of the descriptions for a branch was prepared in the National Roster office from such sources as job descriptions, textbooks, and encyclopedias on a particular subject, and by consultation

with Washington specialists in the various branches of ceramics. A first draft was prepared and distributed to a dozen or more specialists in the field. These men, each with considerable experience in industry, government, or education, were asked to review, criticise, and if necessary to revise the description or any part thereof. The returns were analyzed and many valuable suggestions were incorporated in the final draft, which was then reviewed and approved by Ross C. Purdy, Secretary of The American Ceramic Society, Inc.

III. How It May Be Used

These descriptions were prepared for use of the placement or classification technician concerned with professional personnel. A prior knowledge of the basic activities of a ceramic technologist or engineer in a particular industry or other specialty should enable the technician taking a job order to do a better job of obtaining pertinent and precise information from the employer, and in writing up the request for personnel. Such knowledge should likewise be helpful to the interviewer eliciting job experience information from an applicant or discussing with him employment possibilities.

The technician engaged in coding or classification of applications or registrants on an occupational basis should find this material useful to him. The index will often serve as a useful key in suggesting possible classifications for types of experience which do not immediately and obviously fall into an established classification.

Particular attention is invited to the practical use of the data on related fields. These data broaden the area for the possible placement of applicants with but one specialized type of experience. It is often the case that there are no available positions in the specialized field of the applicant, while there may be vacancies in an allied field in which his experience would be valuable.

DESCRIPTION OF SPECIALIZED PROFESSIONAL FIELDS IN CERAMIC ENGINEERING*

Occupational Summary

The ceramic engineer or technologist is concerned with the raw materials processing and the manufacture of products from clay, silicates, and other nonmetallic minerals, such manufacturing involving the application of high or medium temperatures. It also includes the design and construction of plant equipment and structures. The products include structural materials such as brick, tile, terra cotta, and clay pipe; refractory brick and cements and special refractories; pottery whiteware, including china, porcelain, art and stone ware, and insulators; household, window, and structural glass, and special glass products; enameled metals; abrasives; cements, limes, and plasters.

Little if any distinction can be made between the title of ceramist, ceramic technologist, and ceramic engineer. The latter title is the most inclusive and the one most commonly employed.

Ceramic products are manufactured by any one of five general processes of hardening after the product has been molded. These are as follows:

(1) Products molded in a wet, plastic state and then fired at high temperature (pottery, whiteware, porcelain, and firebrick).

(2) Products which are heated to become fused and molded while in a molten condition (glass).

(3) Products which are pulverized and calcined and which acquire cementlike properties upon the addition of water (cements and plaster).

(4) Glass-base products to which opaque oxides are added, and applied by fusion to metal or glass surfaces (enamels).

(5) Silicon carbide, fused alumina, and natural abrasive grains cemented together at high temperatures by use of ceramic bond or by use of an organic binder (abrasives).

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* All of the specialties described are convertible to code 0.15.11, Ceramic Engineer, in the Dictionary of Occupational Titles.

Functional Activities

Ceramic engineers specialize in any one or more of the well-defined functional areas listed below.

(1) Research and development in (*a*) methods of preliminary processing of raw materials, (*b*) new methods of manufacture and processes, (*c*) correction of defects in product, (*d*) development of new products, (*e*) fundamental research in chemical and physical reactions at all stages of the manufacturing process.

(2) Teaching at the university level—a very limited field.

(3) Plant control—test and check raw materials, equipment operation, process operation, and finished products.

(4) Management and administration—in capacity of production manager, superintendent; coordinates work of various departments; may deal with finances, personnel, purchases, advertising, etc.

(5) Production—supervision of work of various department foremen as forming, drying, firing; also responsible for maintenance of production schedules and quality of product.

(6) Sales and service—determines exact needs of customer and recommends suitable product for the specific service required. Calculates estimate of cost from blueprints and plans and makes estimate of savings in production costs. This engineering service is of most importance in fields of abrasives, refractories, enamels, and structural products.

(7) Design—ceramic plants, kilns, driers, furnaces, conveyers, clayworking machinery; also includes artwork and glazes.

ABRASIVES (45.0.00)

The work of the technologist or engineer in the field of abrasives is divided into two principal specialties.

(1) The production of abrasive grain, which involves either the beneficiation of natural abrasives such as quartz, garnet, emery, and natural corundum, or the manufacture of artificial abrasives such as electric-furnace corundum (fused aluminum oxide) and silicon carbide.

(2) The manufacture of abrasive products such as grinding wheels, coated papers and cloths, lapping compounds, and superrefractories.

The beneficiation of natural abrasives is practically one of mechanical engineering and involves specialized knowledge in the crushing, handling, and sizing by screening of solids as well as their classification, and, in some cases, thermal treatment.

The manufacture of artificial abrasives is highly specialized and involves a knowledge of electrically heated furnaces (arc and electrical resistance furnaces) and high-temperature reactions. This involves a knowledge of industrial electrical furnaces and heating, electrochemistry, crystal structures, thermodynamics, phase rule, and of equipment for crushing and handling of solids.

The manufacture of abrasive ware and other products requires knowledge and training in the specialized fields of ceramic technology, and organic, physical, and industrial chemistry.

The bonds which are used to form the abrasive grain into usable articles are both organic and inorganic. Such products as wheels, segments, honing sticks, sharpening stones, and superrefractories employ principally inorganic ceramic bonds consisting essentially of special types of glasses and silicate compositions. The largest amount of abrasives are bonded in this way. Bonds used in "organic" bonded abrasive products and coated abrasive goods (coated paper and cloth) are synthetic resins and natural resins as shellac, rubber, and glue. "Coated" abrasives are made into sheets, disks, belts, and a variety of small specialties, and are used wherever a flexible abrasive is required.

In addition to having a working knowledge of the basic reactions occurring when these several bonds are matured to form the abrasive product, the abrasives engineer or technologist must also have an understanding of the factors influencing the "grinding action" in service. These factors include (*a*) abrasive grain size and distribution, (*b*)

grade or hardness of the product, (*c*) grain and bond distribution, (*d*) texture (proportions of voids, etc.), (*e*) mechanical properties of the grain, and (*f*) mechanical properties of the bond.

REFRACTORIES (45.0.02)

The refractories technologist or engineer engages in fundamental and applied research, control and direction of manufacturing activities, testing, and occasionally in supervision of related geological and mining activities.

The specialist in this field makes use of such chemical engineering unit operations as materials handling, measurements and storage, mechanical separation and mixing, kneading and pressing. A knowledge of physical chemistry is of importance, especially colloids and phase rule.

The ceramic technologist or engineer deals with

(*a*) Selection of such raw materials as clays, ganister, diaspore, chrome ore, magnesite, and kyanite, used in the manufacture of refractory products.

(*b*) Plant control of moisture content, grain sizing, drying, setting, and firing of refractory brick and shapes, and laboratory control of chemical and physical properties.

(*c*) Research work on the reaction products occurring between furnace linings or crucibles and products manufactured therein.

(*d*) Development of refractories to fit a customer's particular needs and handling customer complaints.

(*e*) Sales engineering work.

The processes which he controls or supervises include semidry pressing, extruding, handmade methods of forming, humidity-controlled drying, slip casting, and electrical fusion of components. Products are fired in coal-, gas-, or oil-fired furnaces. Grinding machinery, mixers, and presses and various systems of conveyers, as belts or cars, are used for transporting materials at different stages of operation.

Professional men in this field usually specialize in the manufacture of a particular class of refractory products. These classes include

(*a*) Fire-clay refractories—covering the general field of materials made from fire clay or diaspore. Glass-tank blocks or pots, steel-pouring refractories, ladle brick, insulating refractories, acid brick, mortars, plastics, and castables are specialized subdivisions in this field, although most of these products are regular firebrick for boilers, furnaces, etc.

(*b*) Silica refractories—made of quartzite or ganister for use in metallurgical and glass furnaces.

(*c*) Basic refractories—made of chrome, lime, magnesia, or magnesium silicates, for use in metallurgical furnaces.

(*d*) Superrefractories—made of silicon carbide, sillimanite, kyanite, andalusite, mullite, zircon, alumina, magnesia, etc., for use under special or extremely severe conditions. These are frequently electric-furnace products.

STRUCTURAL CLAY PRODUCTS (45.0.04)

The ceramic engineer or ceramist in this specialty deals with such classes of products as (*a*) brick, as common, paving, face, acidproof, or ceramic glazed, (*b*) tile, as hollow, drain, floor, roof, wall, and special structure, loadbearing and nonload-bearing, and facing (glazed and specialized), (*c*) conduits and sewer pipe, (*d*) architectural terra cotta, (*e*) miscellaneous products, as flue lining, fireproofing, flashing.

The raw materials are basically clays (surface and fire clay) and shales.

He may employ various chemicals in small amounts as admixtures or surfacings to provide special color effects or glazes. The basic operations consist of clay winning (quarrying or mining), preparation of clay (screening, crushing, grinding, mixing, and tempering), forming of units by various processes, including molding, pressing and extrusion, drying, and firing (burning) in kilns.

Plant operation involves principally maintenance and operations of transportation and forming equipment and apparatus, and drying and combustion control. In general, little testing is carried out in the smaller plants which produce only brick or brick and structural tile. Laboratory work and research, with few exceptions, are done by the ceramic schools or at state and federal research laboratories. The trade associations usually sponsor research. Plants producing glazed ware and many plants producing buff and gray facing brick conduct control tests on their products and many maintain plant laboratories. Much of the research on structural clay products consists in studying their utilization in structures and determining the effect upon properties of differences in raw materials and methods of manufacturing. The techniques are usually physical rather than chemical, inasmuch as plants are seldom large enough to employ separate engineers in these capacities.

Broad technical training is desirable for individuals in this field, including some knowledge of structural engineering, materials handling and equipment, plant layout, fundamentals of electrical engineering, knowledge of wear-resisting materials, production control, and mechanism and fundamentals of machine design.

CEMENTS (45.0.06)

This field deals with the production of Portland, masonry, natural, aluminous, pozzolan, and magnesium oxychloride cements.

The technologists are principally chemists, and chemical, ceramic, or other engineers who deal with preparation of raw materials or with production and control work on manufactured products. The chemist or engineer engages principally in (*a*) fundamental and applied research, (*b*) control and direction of manufacturing activities, and (*c*) chemical analysis of batching materials and of the finished products. The physical tester tests the cement for physical properties such as tensile and compressive strength, fineness, soundness, and time of setting, when fabricated into specimens in accordance with specification or established procedure. The "materials" engineer studies the effect of different properties and methods of manipulation of the cement and concreting materials on the properties of the plastic or the hardened concrete. The production or control engineer or the plant chemist directs changes in raw-mix blends, in burning temperatures and conditions, in grinding procedures and allied production details.

Raw materials for the manufacture of Portland cement consist of limestone and clay, and calcium carbonate, silica, alumina, and other iron oxide-bearing materials. These raw materials are ground and then proportioned in definite ratios, and are heated to incipient fusion in a rotary kiln. The clinker thus obtained plus a small amount of gypsum is ground to the desired fineness in a ball tube mill.

Masonry cements are manufactured in essentially the same manner except that certain materials are added to increase the plasticity. These include hydrated lime, pulverized limestone, diatomaceous earth, or granulated slag, and possible small quantities of calcium stearate or similar material.

Natural cements are formed by calcining a naturally occurring calcareous and clayey material at a temperature below that at which sintering takes place.

Aluminous cements are manufactured by heating until molten a mixture of limestone and bauxite; after cooling, the material is finely ground.

Magnesium oxychloride cement is formed by calcining magnesite to a lightly burnt condition, and combining the ground material with a solution of magnesium chloride at the time the cement is to be used.

Portland pozzolan cement contains Portland cement and pozzolan (volcanic ash, diatomaceous earths, and shales). It is made artificially by calcining certain clays and shales; ground pozzolan is mixed with lime and water to produce a hydraulic cement.

EARTHENWARE AND PORCELAIN (45.0.08)

The ceramic technologist in this specialty deals with the making of various types of china, vitrified stoneware, earthenware, and porcelain products from raw materials which are principally clay, feldspar, quartz, and, in special cases, aluminum oxide or combinations of clay with

alkaline-earth materials and with alumina silica materials. Porcelain is relatively nonporous and glasslike in appearance and is distinguished from earthenware on the basis of these characteristics. The term china is used in England and in this country for vitreous translucent ware, while in continental Europe vitreous translucent dinnerware is called porcelain.

The technologist or engineer may engage in such diverse functions as design of products, process control, research work, or plant operations. The more important unit operations are materials handling, air conditioning, deairing, mixing and agitation, filtration, casting, pugging and extrusion, pumping, forming, drying, firing, glazing, and decorating. In many instances he may be responsible for the extraction and beneficiation of raw materials as well as their classification and disintegration.

The wide variety in physical and chemical properties of earthenware and porcelain are determined and controlled by (*a*) the ratio of clay, feldspar, quartz, and other materials in the mixture, (*b*) the temperature at which these materials are fired, (*c*) the physical condition of the materials, and (*d*) the method employed in forming and in processing.

A considerable amount of research work is carried on in the field and is concerned chiefly with (1) problems of forming, involving the colloid chemistry of aqueous suspensions and the reactions of the clays, and (2) problems of firing involving high-temperature reactions and phase rule studies of silicate systems.

The classes of products in which one may specialize include

(*a*) China, as vitreous art pottery, vitreous cooking ware, and vitreous dinnerware.

(*b*) Earthenware, as semivitreous tableware, nonvitreous art pottery, wall tile.

(*c*) Porcelain, as special chemical and dental ware, high- and low-tension insulators, sanitary ware, sparkplug insulators and specialties, bathroom floor tile, and various industrial, chemical, electrical, and refractory porcelains.

(*d*) Chemical stoneware, important to the chemical industry for processing and handling of corrosive materials.

PORCELAIN ENAMELS (45.0.10)

Enamels used in ceramics, commonly known as porcelain or vitreous enamels, are inorganic compositions, and are applied as glassy coatings to metals and alloys by fusing at or above a red heat. They are used to protect the metal against corrosion when exposed to the weather, when used as containers for food and chemicals, or when heated to high temperatures. They have sanitary properties and also serve to provide a pleasing appearance.

The work of enamel technologists is related to that of other ceramic technologists, especially in the fields of porcelain and glass, because of somewhat similar raw materials and processes of manufacture; hence job transfers within these fields can be made readily.

The enamel technologist controls the process of manufacture, and he studies the effect upon physical and chemical properties produced by varying the compositions, thus developing specialized compositions for specific uses.

Raw materials include cast iron, sheet iron and steel, and other alloys; also silica, feldspar, borax, soda ash, sodium nitrate, fluorspar, cryolite, and the oxides of lead, antimony, zirconium, titanium, cobalt, nickel, etc. The processes with which the technologist deals include casting, fabricating, sandblasting, pickling, and otherwise treating the metal base; also mixing, smelting, fritting, and grinding the coating. Methods of application are generally classified into two groups: (*a*) wet process, used on cast iron, sheet iron, or steel, in which the coating is applied by dipping, spraying, or slushing, followed by drying the coating and firing it on the base; (*b*) dry process, used on cast iron and sanitary ware, in which powdered enamel is applied by sifting directly upon the heated metal. Bins, mixers, smelters, tanks, sprayers, driers, conveyers, sandblasters, dust collectors, brushing and stenciling equipment are used for these processes.

During wartime the most important products are military and naval articles which require protection under severe service conditions, especially high temperatures, also vats and containers for the manufacture of synthetic rubber and other critical products. Normally exteriors and interiors of buildings, sanitary ware, signs, stoves, refrigerators, washing machines, and kitchen equipment are important products which require ceramic enamel coatings.

The field may be divided into three branches, namely, enameled sheet iron and steel, enameled cast iron, and specialties, as enameled copper, jewelry, glass and electrical insulation.

GLASS, PRESSED, BLOWN, AND FLAT (45.0.12)

The specialist in this field deals with the physics, chemistry, engineering, and other technological aspects of the making of vitreous silicate products. The general process involves the heating of the raw materials until they become fluid, then molding or otherwise shaping them while they are in a viscous fluid state, followed by controlled cooling to avoid strains. The materials and processes vary for the production of such classes of products as glass containers, tableware, electrical equipment, glass fibers, laminated, plate, and window glasses, illuminated glassware, chemical glassware, optical blanks, and fused silica (quartz) products.

The chief raw materials used in glassmaking are compounds of silicon, calcium, magnesium, and sodium; principally quartz sand, dolomite, limestone, lime, calcium carbonate, feldspar, soda ash, borax, salt cake, and niter. Many other inorganic chemicals are used in small quantities to impart special properties to glass.

Glass technologists may engage in any of the following functions in glass production.

(*a*) Research and development work on raw materials, processes, or products.

(*b*) Design and construction of equipment or plant.

(*c*) Process control.

(*d*) Analytical control and testing.

(*e*) Over-all production supervision or administrative work.

(*f*) Other, as teaching, safety, sales and service, and consulting work.

Glass technologists deal with the following steps in glass production:

(1) Formulation and control of glass compositions to give the desired chemical and physical properties to the final product.

(2) The design and operation of glassmelting furnaces (tanks and pots) for different classes of products. This is related to refractories (45.0.02) and industrial furnaces (47.9.16).

(3) Supervision of the forming operations, and improvement of machinery and molds used to shape glass by such processes as (*a*) pressing (tumblers, tableware, special shapes), (*b*) blowing (hollow ware, light bulbs), (*c*) drawing (sheet glass, tubing), (*d*) casting (plate glass, special shapes), (*e*) special processes (glass fiber and foam glass).

(4) Annealing—the exacting control of time-temperature relationships which includes lehr (oven) operation and development.

(5) Finishing of products, as rim treatment, etc.

(6) Decorating, as engraving, acid etching, and low-temperature enameling. Includes control and improvement of design application.

(7) Heat-treating—quenching, tempering (oil and air), and reannealing.

(8) Testing and inspection of raw materials and of finished products. This includes the establishment of quality standards and of equipment for production control.

PRECISION OPTICAL GLASS (45.0.14)

Optical glass must be manufactured of unusually pure batch materials, melted, molded, annealed, and finished under carefully controlled conditions, and rigidly inspected for imperfections. Glass technologists are concerned with

the processes of manufacture, their control and improvement, and the development of new glasses. Among their activities are

(1) Developing compositions that will give the desired characteristics of good optical glass. These include homogeneity (freedom from striae, bubbles, and cloudiness), a control of the refractive index and other optical properties, freedom from color, high degree of transparency, and high degree of chemical and physical stability (as hardness and resistance to weather and chemical agents).

(2) Testing batch materials for chemical purity and physical properties and control of weighing and mixing of batch compositions.

(3) Establishing time-temperature schedules for the melting, firing, charging, stirring; also for heating and firing glassmelting pots and stirring tubes.

(4) Determining the resistance of refractories to glass attack.

(5) Measuring optical and physicochemical properties of glass.

(6) Establishing standards and equipment for the inspection of rough and molded optical glass.

(7) Determining the operating characteristics of glass furnaces, glory holes, and auxiliary equipment and establishing controls.

(8) Improving and controlling techniques of molding lens blanks, and establishing of time-temperature schedules for their annealing.

Closely allied fields with which the glass technologist is generally familiar include heat generation and exchange (41.0.26), industrial furnaces (49.7.16), refractories (45.0.-02), phase rule (40.1.48), physics—light (30.3.70), physical chemistry (40.1.49), and surface chemistry (40.1.59).

GYPSUM (45.0.18)

Gypsum is the raw material used in the manufacture of plaster of Paris (calcined gypsum) and related cements and plasters. These hydrate cementing materials or plasters are manufactured by driving water off gypsum; their setting properties are due to recombining with water.

Related fields are alkali and alkaline earth metals and compounds, n.e.c. (40.5.20), and cements (45.0.06).

The technologist is concerned with the composition, mining or quarrying, and sizing of the gypsum or gypsite; the calcination (removal of water) of the gypsum in kettles or kilns to produce plaster of Paris or related cements; the addition of the proper retarders or accelerators to regulate the time of set of the plasters; the manufacture of gypsum products, such as gypsum building block or tile, gypsum wall board, plaster board or lath and gypsum sheathing board from the calcined gypsum, and other gypsum products used in chemical, metallurgical, paint, paper, ceramic and allied industries; and the development and manufacture of special plasters, cements, and fillers from various types of calcined gypsum.

The technologist usually possesses some knowledge of the geology and beneficiation of nonmetallic minerals and the construction and operation of kettles, kilns, and machinery for the manufacture of gypsum board and block products. In this connection he must be familiar with fuels and combustion technology and with many unit operations in chemical engineering. He usually possesses a knowledge of the needs of those industries that use gypsum and gypsum products, such as the ceramic industry, for pottery molding, and nonferrous metallurgy for foundry practices.

In addition the technologist should be acquainted with the physical testing of gypsum products, such as the time of set, fineness, and strength.

The larger concerns also employ specialists trained in research in physical or inorganic chemistry, and in physics research, as in sound measurements of plaster, heat transfer, and fire resistance.

LIME (45.0.20)

The specialist in this field deals with the chemistry, manufacture, and uses of the oxides, hydroxides, and carbonates of calcium and magnesium. It is allied to the field of alkali and alkaline earth metals and compounds, n.e.c. (40.5.20), and also to refractories (45.0.02), since lime technologists often are responsible for the production of dead-burned dolomite, which is used for refractory purposes in metallurgical furnaces.

The technologist is concerned with the composition, mining, and sizing of the limestone (carbonates of calcium and magnesium); the burning of the limestone in kilns to produce quicklime (oxides of calcium and magnesium); the hydration or slaking of the quicklime to produce hydrated lime (hydroxides of calcium and magnesium); the sizing of the quicklime or hydrated lime to vary the properties of the product; the uses of these compounds in the chemical and metallurgical industries, in the structural field, and in agriculture.

He may possess knowledge of kiln construction and operation, including fuels and combustion, operation of hydrators, and of analytical and surface chemistry.

Larger concerns employ research specialists to develop new types of lime products for special uses.

(1944)

ISADORE MOCKRIN AT BATTELLE

Isadore Mockrin, a member of The American Ceramic Society, has been named to the staff of the Battelle Memorial Institute, Columbus, Ohio, and assigned to its division of ceramic research.

Isadore Mockrin

Mr. Mockrin, who was formerly an associate chemist of the National Bureau of Standards, Washington, D. C., holds a Bachelor of Science degree in chemical engineering from the University of Pennsylvania and has attended George Washington University. He is also affiliated with the American Chemical Society.

At Battelle, Mr. Mockrin will be engaged in research in glass technology, a field in which he was active while associated with the National Bureau of Standards.

47th ANNUAL MEETING
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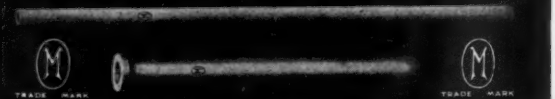

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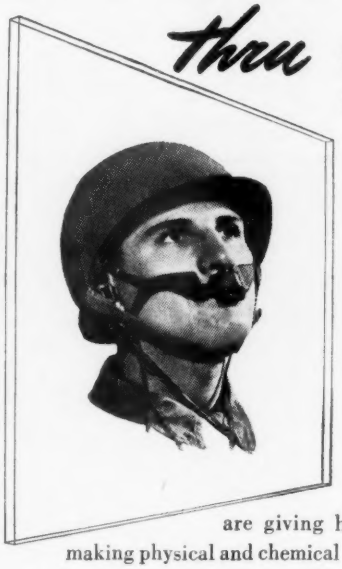
LOOK TO THE FUTURE *thru Glass!*



GLASS WASHERS for lip microphones of tomorrow

Shades of ancient glass!—today's new methods and materials are giving high-grade glass epoch-making physical and chemical properties—in new forms and types that reveal exciting future uses for interesting post-war products.

Tradition shattering is this imaginative application of high-grade fibre glass as tiny washers for the new lip microphone. Newly perfected and inherent qualities of glass make the washers moisture proof, shock-absorbent, distortion proof, and suitable for sound transmission.

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Photo courtesy of Electro-Voice Mfg Co., Inc.

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Calcined Dustless Potassium Carbonate 99-100% K_2CO_3

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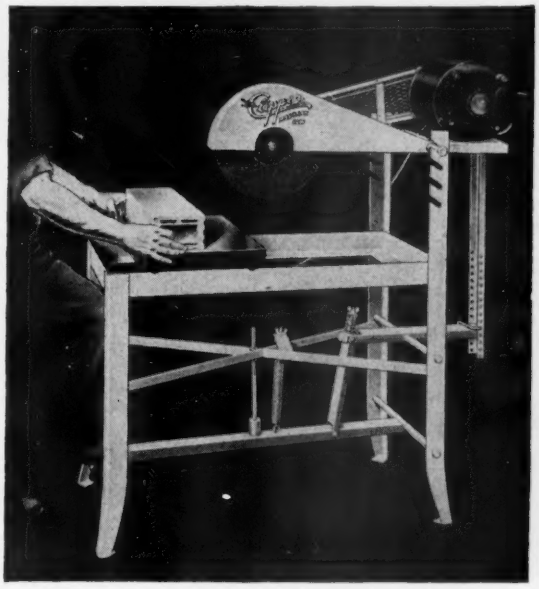
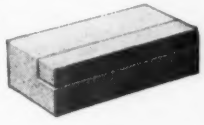
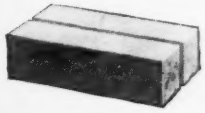


The new Clipper Multiple Cutting Principle makes possible faster cutting of every masonry material regardless of hardness. Here are a few typical examples:

This acid brick intended for a chemical plant acid chamber was cut completely in two, in just 37 seconds.

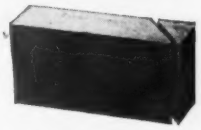
One of many intricate cuts performed on first quality clay brick for heat treating furnaces. Made in 8 sec.





Silica brick cut lengthwise for open hearth furnace work, only 9 seconds were required to complete this cut!

Basic refractories for steel furnaces or cement kilns must be accurately installed. This magnesite brick was cut in 12 seconds.



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Vitro Mfg. Co.

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Maxson, Elwyn L.
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Corhart Refractories Co.

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Hammill & Gillespie, Inc.
Harshaw Chemical Co.
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Maxson, Elwyn L.

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Vitrifiable Colors for Banding, Spraying and Screening; Fluxes; Batch Colors; Alkali Resisting, Acid Resisting, Satin Matt Finish, High Fire Convexing, Low Fire, and Squeegee Colors; White or Colored Weather Resisting Enamels; Colored or Crystal Ices; and Decorating Supplies.

ENAMEL

Colors and Oxides; Smelter Oxides; Graining, Printing, Banding, Screening and Decalcomania Colors; Chemicals, and Mill Room Supplies.

CERAMIC COLOR & CHEMICAL MFG. CO... NEW BRIGHTON, PA.

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"G-1 REFRACTORY WHITE CLAY"

Infallible for High-Duty Clay Refractories

- Great Refractoriness (Cone 34),
- High Plasticity,
- Enormous Load-Carrying Capacity,
- Good Resistance to Slagging and Corrosion.

Absolutely uniform and pure (Appr. 98% clay substance). A money-saver because of longer life through greater strength.

IN CLAY CASTING a small percentage of "G-1" added to body mix gives faster casting rates; eliminates drying and burning cracks; stabilizes the properties of casting slip, drying cast ware with more ease; and leaves cast ware in perfect, leather-hard condition with no "drooping" after mold is removed.

THIRTY years in successful, practical use—millions of tons available—furnished crude, air-dried, oven-dried, crushed, or pulverized. Prompt shipments, Georgia clay tariff rates.

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March 1944 Bulletin

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October 1933 Journal

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2525 N. High St., Columbus, Ohio

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Harshaw Chemical Co.
Hommel, O., Co., Inc.
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Maxson, Elwyn L.
Pemco Corp.
Vitro Mfg. Co.

Filter Fabrics
Metakloth Company

Fire Brick
Carborundum Co.
Corhart Refractories Co.
Electro Refractories & Alloys Corp.
Green, A. P., Fire Brick Co.
Norton Co.
Remmey, Richard C., Son Co.

Fire Brick—Process Equipment
Lancaster Iron Works, Inc.

Fire Clay
Great Lakes Foundry Sand Co.
Spinks, H. C., Clay Co.

Flint
Ceramic Color & Chemical Mfg. Co.
Clinchfield Sand & Feldspar Corp.
Du Pont de Nemours, E. I., & Co., Inc., Electrochemicals Dept.
Great Lakes Foundry Sand Co.
Harshaw Chemical Co.
Hommel, O., Co., Inc.
Maxson, Elwyn L.
Pemco Corp.

Flint Pebbles
Ceramic Color & Chemical Mfg. Co.
Clinchfield Sand & Feldspar Corp.
Eureka Flint & Spar Co.
Hommel, O., Co., Inc.
Ingram-Richardson Mfg. Co. of Indiana, Inc.
Vitro Mfg. Co.

Flint (Soft decomposed Cararra)
Innis, Speiden & Co.

Floors (Non-Slip)
Norton Co.

Fluorspar
Ceramic Color & Chemical Mfg. Co.
Harshaw Chemical Co.
Hommel, O., Co., Inc.

French Flint
Eureka Flint & Spar Co.
Maxson, Elwyn L.

Frit
Ceramic Color & Chemical Mfg. Co.
Chicago Vitreous Enamel Product Co.
Ferro Enamel Corp.
Harshaw Chemical Co.
Hommel, O., Co., Inc.
Ingram-Richardson Mfg. Co. of Indiana, Inc.
Pemco Corp.
Titanium Alloy & Mfg. Co.
Vitro Mfg. Co.

Frosting Mixtures
Drakenfeld, B. F., & Co., Inc.
Harshaw Chemical Co.
Hommel, O., Co., Inc.

Fuel Oil Systems and Control Stokers
Frazier-Simplex, Inc.
Harrop Ceramic Service Co.

Furnaces
Carborundum Co. (*Carboradient*)
Ferro Enamel Corp.
Frazier-Simplex, Inc.
Harrop Ceramic Service Co.
Hommel, O., Co., Inc.
Ingram-Richardson Mfg. Co. of Indiana, Inc.
Swindell-Dressler Corp.

Furnaces (Laboratory)
Remmey, Richard C., Son Co.

Furnaces, Enameling
Ferro Enamel Corp.
Swindell-Dressler Corp.

Gauges, Draft (Recording, Indicating)
Hays Corp.
Leeds & Northrup Co.

Gauges, Flow (Air and Gas)
Hays Corp.

Gauges, Pressure
Hays Corp.
Leeds & Northrup Co.

Gauges, Ratio (Flows)
Hays Corp.

Glass Bending Ovens, Glass Decorating Machines
Frazier-Simplex, Inc.

Glass Equipment
Lancaster Iron Works, Inc.

Glass Melting Tanks and Furnaces
Frazier-Simplex, Inc.

Glass Sand
Great Lakes Foundry Sand Co.

Glass Thickness Gauge
Bausch & Lomb Optical Co.

Glaze and Body Spar
Clinchfield Sand & Feldspar Corp.
Du Pont de Nemours, E. I., & Co., Inc., Electrochemicals Dept.
Eureka Flint & Spar Co.
Harshaw Chemical Co.
Hommel, O., Co., Inc.
Maxson, Elwyn L.
Pemco Corp.
Vitro Mfg. Co.

Glazes and Enamels
Ceramic Color & Chemical Mfg. Co.
Drakenfeld, B. F., & Co., Inc.
Du Pont de Nemours, E. I., & Co., Inc., Electrochemicals Dept.
Ferro Enamel Corp.
Harshaw Chemical Co.
Hommel, O., Co., Inc.
Ingram-Richardson Mfg. Co. of Indiana, Inc.
Pemco Corp.
Titanium Alloy & Mfg. Co.
Vitro Mfg. Co.

Glaze Spar
Ceramic Color & Chemical Mfg. Co.
Clinchfield Sand & Feldspar Corp.
Du Pont de Nemours, E. I., & Co., Inc., Electrochemicals Dept.
Eureka Flint & Spar Co.
Harshaw Chemical Co.
Hommel, O., Co., Inc.
Maxson, Elwyn L.

Goggles
Hommel, O., Co., Inc.
Willson Products, Inc.

Gold
Ceramic Color & Chemical Mfg. Co.
Drakenfeld, B. F., & Co., Inc.
Du Pont de Nemours, E. I., & Co., Inc., Electrochemicals Dept.
Harshaw Chemical Co.
Hommel, O., Co., Inc.
Vitro Mfg. Co.

Gold Decorations
Ceramic Color & Chemical Mfg. Co.
Du Pont de Nemours, E. I., & Co., Inc., Electrochemicals Dept.
Hommel, O., Co., Inc.

Granulators
Lancaster Iron Works, Inc.

Grinding Wheels
Carborundum Co. (*Carborundum and Aloxite*)
Chicago Vitreous Enamel Product Co.
Electro Refractories & Alloys Corp.
Norton Co. (*Alundum-Crystolon*)

Gums: *Arabic*—Amber Sorts, Powdered, Grained
Ghatti—Powdered, Granular, Crude
Locust Bean—Powdered
Tragacanth—Ribbon—Flake—Powdered
Innis, Speiden & Co.

Hearths
Carborundum Co. (*Carbofrax* heat treating)
Corhart Refractories Co.
Norton Co. (*Crystolon*)
Remmey, Richard C., Son Co.

Hearths (High Aluminous Clay, Electrically Sintered Aluminum Oxide, Silicon Carbide)
Carborundum Co.
New Castle Refractories Co.
Norton Co.
Remmey, Richard C., Son Co.

Hydraulic Propellers
Denison Engineering Co.

Hydrofluoric Acid
Harshaw Chemical Co.
Hommel, O., Co., Inc.

Ilmenite
Orefraction, Inc.

Iron Chromite
Harshaw Chemical Co.

Iron (Enameling)
American Rolling Mill Co.

Iron Oxide
Ceramic Color & Chemical Mfg. Co.
Drakenfeld, B. F., & Co., Inc.
Du Pont de Nemours, E. I., & Co., Inc., Electrochemicals Dept.
Foote Mineral Co.
Harshaw Chemical Co.
Hommel, O., Co., Inc.
Pemco Corp.
Vitro Mfg. Co.

Kaolin
Ceramic Color & Chemical Mfg. Co.
Hammill & Gillespie, Inc.
Harshaw Chemical Co.
Hommel, O., Co., Inc.
Maxson, Elwyn L.
United Clay Mines Corp.
Vitro Mfg. Co.

Kiln Furniture (Silicon Carbide, Semi-Silicon Carbide) (Refractory)
Carborundum Co.
Electro Refractories & Alloys Corp.
Ferro Enamel Corp.—Ceramic Supply Div.
Remmey, Richard C., Son Co.

Kilns, China (Decorating)
Drakenfeld, B. F., & Co., Inc.
Ferro Enamel Corp.—Allied Engineering Div.
Frazier-Simplex, Inc.
Harrop Ceramic Service Co.
Hommel, O., Co., Inc.
Swindell-Dressler Corp.

Kilns (Electric, Circular, Tunnel)
Ferro Enamel Corp.—Allied Engineering Div.
Harrop Ceramic Service Co.
Swindell-Dressler Corp.

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Remmey, Richard C., Son Co.

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Pennsylvania Salt Mfg. Co.

Laboratory Ware
Norton Co.

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Electro Refractories & Alloys Corp.
New Castle Refractories Co.

Lehrs
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Swindell-Dressler Corp.

Lehrs (Electric or Fuel Heated)
Frazier-Simplex, Inc.
Swindell-Dressler Corp.

Lehr Loaders
Frazier-Simplex, Inc.

Linings (Furnace Refractory, Block Refractory Plate, Brick, and Tile)
Carborundum Co.
Corhart Refractories Co.
Electro Refractories & Alloys Corp.
Green, A. P., Fire Brick Co.
Ingram-Richardson Mfg. Co. of Indiana, Inc.
Norton Co.
Remmey, Richard C., Son Co.
Vitro Mfg. Co.

Lithium Carbonate
Ceramic Color & Chemical Mfg. Co.
Drakenfeld, B. F., & Co., Inc.
Foote Mineral Co.
Hommel, O., Co., Inc.

Lithium Minerals
Foote Mineral Co.

Magnesia (Fused)
Electro Refractories & Alloys Corp.
Norton Co.

Magnesia (Sintered, Calcined)
Ceramic Color & Chemical Mfg. Co.
Drakenfeld, B. F., & Co., Inc.
Du Pont de Nemours, E. I., & Co., Inc., Electrochemicals Dept.
Harshaw Chemical Co.
Hommel, O., Co., Inc.
Pemco Corp.

Magnesite
Ceramic Color & Chemical Mfg. Co.
Drakenfeld, B. F., & Co., Inc.
Du Pont de Nemours, E. I., & Co., Inc., Electrochemicals Dept.
Foote Mineral Co.
Hammill & Gillespie, Inc.
Harshaw Chemical Co.
Hommel, O., Co., Inc.
Vitro Mfg. Co.

Magnesite Calcined
Ceramic Color & Chemical Mfg. Co.
Foote Mineral Co.
Hommel, O., Co., Inc.

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and Plant

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Drakenfeld, B. F., & Co., Inc.
Ferro Enamel Corp.
Harshaw Chemical Co.
Hommel, O., Co., Inc.

Manganese
Ceramic Color & Chemical Mfg. Co.
Drakenfeld, B. F., & Co., Inc.
Du Pont de Nemours, E. I., & Co., Inc., Electrochemicals Dept.
Ferro Enamel Corp.
Hammill & Gillespie, Inc.
Harshaw Chemical Co.
Hommel, O., Co., Inc.
Vitro Mfg. Co.

Manganese Dioxide
Ceramic Color & Chemical Mfg. Co.
Drakenfeld, B. F., & Co.
Ferro Enamel Corp.
Foote Mineral Co.
Hommel, O., Co., Inc.

Manganese (Oxide)
Ceramic Color & Chemical Mfg. Co.
Corhart Refractories Co.
Drakenfeld, B. F., & Co., Inc.
Du Pont de Nemours, E. I., & Co., Inc., Electrochemicals Dept.
Ferro Enamel Corp.
Harshaw Chemical Co.
Hommel, O., Co., Inc.

Masks (Breathing)
Drakenfeld, B. F., & Co., Inc.
Hommel, O., Co., Inc.
Willson Products, Inc.

Metals (Porcelain Enameling)
American Rolling Mill Co.

Micronized Products
Pemco Corp.

Microscopes (Polarizing)
Bausch & Lomb Optical Co.
Spencer Lens Co.

Microscopes (Stereoscopic)
Bausch & Lomb Optical Co.
Spencer Lens Co.

Minerals
Ceramic Color & Chemical Mfg. Co.
Clinchfield Sand & Feldspar Corp.
Drakenfeld, B. F., & Co., Inc.
Du Pont de Nemours, E. I., & Co., Inc., Electrochemicals Dept.
Foote Mineral Co.
Hammill & Gillespie, Inc.
Harshaw Chemical Co.
Hommel, O., Co., Inc.
Orefraction, Inc.
Vitro Mfg. Co.

Mixers
Clearfield Machine Co.

Mixers (Batch)
Clearfield Machine Co.
Lancaster Iron Works, Inc.

Mixers (Concrete, Paving, Road Paving, Plaster, Asphalt, Truck, Mortar, Bituminous)
Lancaster Iron Works, Inc.

Mixers (Laboratory)
Lancaster Iron Works, Inc.

Mold Sanders
Lancaster Iron Works, Inc.

Muffles (Furnace) (Laboratory)
Carborundum Co. (*Carbofrax*)
Electro Refractories & Alloys Corp.
Frazier-Simplex, Inc.
Ingram-Richardson Mfg. Co. of Indiana, Inc.
Norton Co.
Remmey, Richard C., Son Co.

Mullers (Batch)
Clearfield Machine Co.
Lancaster Iron Works, Inc.

Mullite Refractories
Remmey, Richard C., Son Co.

Muriatic Acid
Harshaw Chemical Co.
Hommel, O., Co., Inc.
Pennsylvania Salt Mfg. Co.

Needle Antimony
Ceramic Color & Chemical Mfg. Co.
Foote Mineral Co.
Harshaw Chemical Co.
Hommel, O., Co., Inc.

Nepheline Syenite
Great Lakes Foundry Sand Co.

Nickel Salts
Ceramic Color & Chemical Mfg Co.
Drakenfeld, B. F., & Co., Inc.
Harshaw Chemical Co.
Hommel, O., Co., Inc.

Nitrates (Cobalt, Sodium)
Ceramic Color & Chemical Mfg. Co.
Drakenfeld, B. F., & Co., Inc.
Du Pont de Nemours, E. I., & Co., Inc., Electrochemicals Dept.
Harshaw Chemical Co.
Hommel, O., Co., Inc.
Vitro Mfg. Co.

Nitre
Ceramic Color & Chemical Mfg. Co.
Harshaw Chemical Co.
Hommel, O., Co., Inc.

Norbide (Norton Boron Carbide)
Norton Co.

Olivine
Clinchfield Sand & Feldspar Corp.
Du Pont de Nemours, E. I., & Co., Inc., Electrochemicals Dept.

Opacifiers
Ceramic Color & Chemical Mfg. Co.
Drakenfeld, B. F., & Co., Inc.
Du Pont de Nemours, E. I., & Co., Inc., Electrochemicals Dept.
Harshaw Chemical Co.
Hommel, O., Co., Inc.
Ingram-Richardson Mfg. Co. of Indiana, Inc.
Metal & Thermit Corp.
Pemco Corp.
Pennsylvania Salt Mfg. Co.
Titanium Alloy & Mfg. Co.
Vitro Mfg. Co.

Overglaze Colors
Ceramic Color & Chemical Mfg. Co.
Drakenfeld, B. F., & Co., Inc.
Du Pont de Nemours, E. I., & Co., Inc., Electrochemicals Dept.
Ferro Enamel Corp.
Hommel, O., Co., Inc.

Oxides
Ceramic Color & Chemical Mfg. Co.
Chicago Vitreous Enamel Product Co.
Drakenfeld, B. F., & Co., Inc.
Du Pont de Nemours, E. I., & Co., Inc., Electrochemicals Dept.
Ferro Enamel Corp.
Harshaw Chemical Co.
Hommel, O., Co., Inc.
Ingram-Richardson Mfg. Co. of Indiana, Inc.
Metal & Thermit Corp.
Pemco Corp.
Titanium Alloy & Mfg. Co.
Vitro Mfg. Co.

Palladium Decorations
Du Pont de Nemours, E. I., & Co., Inc., Electrochemicals Dept.
Hommel, O., Co., Inc.

Pans—Wet and Dry
Clearfield Machine Co.

Pins
Hommel, O., Co., Inc.
Industrial Ceramic Products, Inc.
Ingram-Richardson Mfg. Co. of Indiana, Inc.
Potters Supply Co.

Placing Sand
Great Lakes Foundry Sand Co.
United Clay Mines Corp.

Platinum Decorations
Du Pont de Nemours, E. I., & Co., Inc., Electrochemicals Dept.
Hommel, O., Co., Inc.

Polariscopes
Bausch & Lomb Optical Co.
Frazier-Simplex, Inc.

Porcelain Enameling Service (Practical)
American Rolling Mill Co.
Ceramic Color & Chemical Mfg. Co.
Chicago Vitreous Enamel Product Co.
Du Pont de Nemours, E. I., & Co., Inc., Electrochemicals Dept.
Ferro Enamel Corp.
Hommel, O., Co., Inc.
Ingram-Richardson Mfg. Co. of Indiana, Inc.
Pemco Corp.
Titanium Alloy & Mfg. Co.
Vitro Mfg. Co.

Porcelain Enamels
Ceramic Color & Chemical Mfg. Co.
Chicago Vitreous Enamel Product Co.
Ferro Enamel Corp.
Hommel, O., Co., Inc.
Ingram-Richardson Mfg. Co. of Indiana, Inc.
Pemco Corp.
Titanium Alloy & Mfg. Co.
Vitro Mfg. Co.

Potash (Carbonate)
Ceramic Color & Chemical Mfg. Co.
Chicago Vitreous Enamel Product Co.
Du Pont de Nemours, E. I., & Co., Inc., Electrochemicals Dept.
Harshaw Chemical Co.
Hommel, O., Co., Inc.
Innis, Speiden & Co.
Vitro Mfg. Co.

Potassium Hydroxide
Innis, Speiden & Co.

Pressure Gauges, Tank
Hays Corp.

Producer Glass Plants
Frazier-Simplex, Inc.

Pug Mills
Lancaster Iron Works, Inc.

Pyrites (Natural Iron Sulphide)
Ceramic Color & Chemical Mfg. Co.
Foote Mineral Co.
Hommel, O., Co., Inc.

Pyrometer Tubes
Carborundum Co.
Leeds & Northrup Co.
Montgomery Porcelain Products Co.

Pyrometer Tubes (Refractory and Hard Porcelain)
Electro Refractories & Alloys Corp.
McDanel Refractory Porcelain Co.
Montgomery Porcelain Products Co.
Norton Co.

Pyrometers (Optical, Radiation, Surface, Immersion, Needle)
Leeds & Northrup Co.

Pyrometric Cones
Edward Orton, Jr., Ceramic Foundation

Pyrophyllite
Clinchfield Sand & Feldspar Corp.

Quartz (Granulated)
Clinchfield Sand & Feldspar Corp.

Raw Material Handling Equipment
Frazier-Simplex, Inc.
Lancaster Iron Works, Inc.

Recorders, CO_2
Hays Corp.
Leeds & Northrup Co.

Recorders, Draft
Hays Corp.
Leeds & Northrup Co

Recorders, Tank Pressure
Hays Corp.
Leeds & Northrup Co.

Refractometers
Bausch & Lomb Optical Co.
Electro Refractories & Alloys Corp.
Green, A. P., Fire Brick Co.
Spencer Lens Co.

Refractories
Carborundum Co.
Corhart Refractories Co.
Electro Refractories & Alloys Corp.
New Castle Refractories Co.
Norton Co.
Remmey, Richard C., Son Co.

Refractory Materials
Carborundum Co.
Corhart Refractories Co.
Electro Refractories & Alloys Corp.
Green, A. P., Fire Brick Co.
Norton Co.
Remmey, Richard C., Son Co.
Titanium Alloy & Mfg. Co.

Respirators
Drakenfeld, B. F., & Co., Inc.
Hommel, O., Co., Inc.
Willson Products, Inc.

Rutile
Ceramic Color & Chemical Mfg. Co.
Drakenfeld, B. F., & Co., Inc.
Du Pont de Nemours, E. I., & Co., Inc., Electrochemicals Dept.
Foote Mineral Co.
Harshaw Chemical Co.
Hommel, O., Co., Inc.
Metal & Thermit Corp.
Orefraction, Inc.
Vitro Mfg. Co.
Willson Products, Inc.

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THE USE OF VOLCLAY BENTONITE IN THE CLAY WORKING INDUSTRY IS CONSTANTLY GROWING. SMALL AMOUNTS IMPROVE THE WORKABILITY AND FIRED PROPERTIES OF CLAY PRODUCTS.

FOR SIXTEEN YEARS THE TOP QUALITY COLLOIDAL BENTONITE

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Fans and Blowers for the Ceramic Industry

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Place your air handling problems in our hands... Our 50 years' experience assures efficient results.

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Zinc Oxide : Enameling Clays : Etc.

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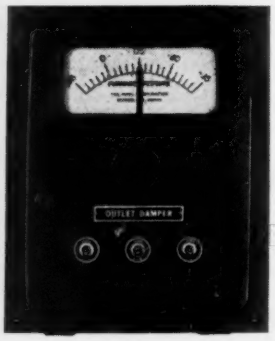
225 Broadway New York

CONTROL AND YOU Save!

Below is pictured the Hays Automatic Tank Pressure Controller Type CDE-X which is typical of Hays Controllers. It is provided with a manual adjusting knob accessible from front of case for setting the Controller for the differential pressure to be maintained. Indicator and scales indicate differential or furnace pressure for which the Controller is set.



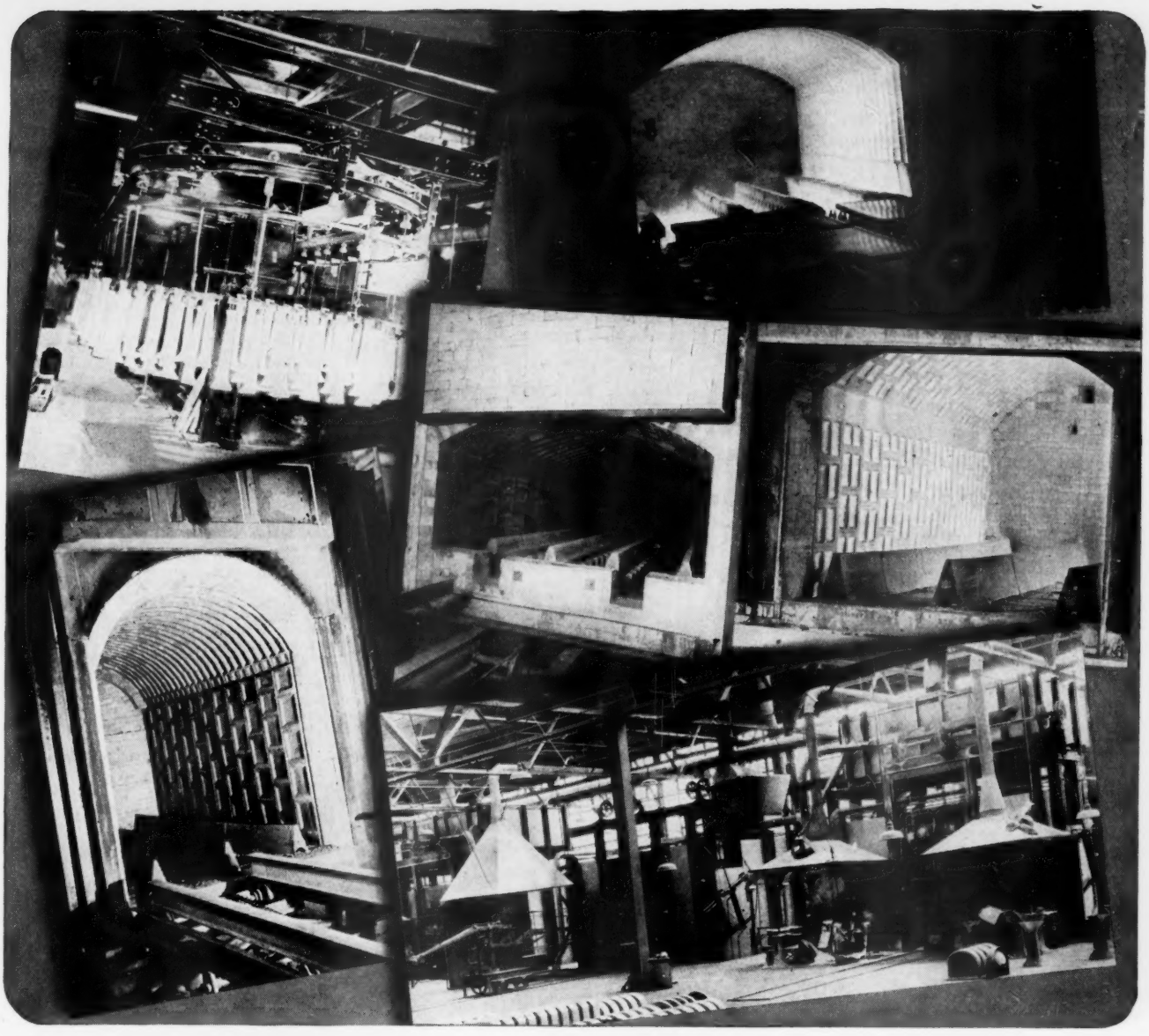
SAVE in time, materials, fuel, man-power; minimize spoilage and guarantee a better, more uniform product.

Hays Instruments for the Ceramic Field include air and gas measuring, indicating and recording Gages, draft and pressure Indicators and Recorders, Gas-Air Ratio Meters, Oil-Air Proportioning Meters, Combustion Meters, CO_2 Recorders and complete Systems of Automatic Combustion Control.

Bulletins 43-552 and 43-591 explain the application of Instruments and Controllers to Ceramic furnaces, Glass tanks, Pottery kilns and Enameling furnaces with schematic drawing of a complete system of Automatic Control of Combustion and Pressures—sent free upon request.

SPECIAL NOTE! Be sure to send for your Free Copy of Bulletin 43-552 "Instrumentation and Control of Ceramic Furnaces, Pottery Kilns, Glass Tanks and Enameling Furnaces."

The HAYS CORPORATION
SINCE 1901 COMBUSTION INSTRUMENTS AND CONTROL
MICHIGAN CITY, INDIANA, U.S.A.



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. . . CALL IN CARBORUNDUM and take advantage of wide experience in producing and applying super refractories to porcelain enameling furnaces.

Where furnaces are operated at high production rates, "Carbofrax" muffles are usually the best choice. With a thermal conductivity 11 to 12 times that of fire clay, "Carbofrax" provides the rapid, uniform heat transfer needed to ensure quicker comeback—faster operation—reduced fuel costs. A further dividend is the longer life secured from improved varieties of "Carbofrax."

For those furnaces in which peak capacity is not a prime objective, "Alfrax" muffles are available. The chemical stability of "Alfrax" means long life, few replacements and continuous service. Fuel costs, too, are kept low, as "Alfrax" has a thermal conductivity 4 times that of fire clay.

Installation after installation has proved the merit of *Carborundum Brand* super refractories—*and* the value of Carborundum's engineering service in recommending the correct refractory for specific operating conditions. The Carborundum Company, Refractories Division, Perth Amboy, N. J.

See our 16-page insert in the Ceramic Data Book!

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Super Refractories by CARBORUNDUM TRADE MARK

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Saggers
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Electro Refractories & Alloys Corp.
Ferro Enamel Corp.—Ceramic Supply Div.
New Castle Refractories Co.
Norton Co.
Potters Supply Co.
Remmey, Richard C., Son Co.

Salt Cake
American Potash & Chemical Corp.
Drakenfeld, B. F., & Co., Inc.
Harshaw Chemical Co.
Hommel, O., Co., Inc.
Pennsylvania Salt Mfg. Co.

Sandblast Sand
Great Lakes Foundry Sand Co.

Sand Grinders and Sifters
Lancaster Iron Works, Inc.

Selenite of Sodium
Ceramic Color & Chemical Mfg. Co.
Drakenfeld, B. F., & Co., Inc.
Hommel, O., Co., Inc.
Vitro Mfg. Co.

Selenium
Ceramic Color & Chemical Mfg. Co.
Drakenfeld, B. F., & Co., Inc.
Du Pont de Nemours, E. I., & Co., Inc., Electrochemicals Dept.
Foote Mineral Co.
Harshaw Chemical Co.
Hommel, O., Co., Inc.
Vitro Mfg. Co.

Sheets (Enameling Iron)
American Rolling Mill Co.

Silica (Fused)
Electro Refractories & Alloys Corp.
Foote Mineral Co.
Hommel, O., Co., Inc.

Silicate of Soda
Ceramic Color & Chemical Mfg. Co.
Harshaw Chemical Co.
Hommel, O., Co., Inc.

Silicon Carbide
Carborundum Co.
Electro Refractories & Alloys Corp.
New Castle Refractories Co.
Norton Co.

Silicon Carbide Firesand
Carborundum Co.

Sillimanite Refractories
Electro Refractories & Alloys Corp.
Remmey, Richard C., Son Co.

Slabs (Furnace)
Carborundum Co.
Electro Refractories & Alloys Corp.
Ingram-Richardson Mfg. Co. of Indiana, Inc.
New Castle Refractories Co.
Norton Co.
Remmey, Richard C., Son Co.

Soda Ash
American Potash & Chemical Corp.
Ceramic Color & Chemical Mfg. Co.
Chicago Vitreous Enamel Product Co.
Du Pont de Nemours, E. I., & Co., Inc., Electrochemicals Dept.
Harshaw Chemical Co.
Hommel, O., Co., Inc.
Pennsylvania Salt Mfg. Co.
Vitro Mfg. Co.

Sodium Antimonate
Ceramic Color & Chemical Mfg. Co.
Drakenfeld, B. F., & Co., Inc.
Du Pont de Nemours, E. I., & Co., Inc., Electrochemicals Dept.
Harshaw Chemical Co.
Hommel, O., Co., Inc.
Metal & Thermit Corp.
Vitro Mfg. Co.

Sodium Fluoride
Ceramic Color & Chemical Mfg. Co.
Drakenfeld, B. F., & Co., Inc.
Du Pont de Nemours, E. I., & Co., Inc., Electrochemicals Dept.
Harshaw Chemical Co.
Hommel, O., Co., Inc.
Vitro Mfg. Co.

Sodium Metasilicate
Harshaw Chemical Co.
Innis, Speiden & Co.

Sodium Nitrite
Ceramic Color & Chemical Mfg. Co.
Chicago Vitreous Enamel Product Co.
Harshaw Chemical Co.
Hommel, O., Co., Inc.

Sodium Orthosilicate
Innis, Speiden & Co.

Sodium Silica Fluoride
Ceramic Color & Chemical Mfg. Co.
Du Pont de Nemours, E. I., & Co., Inc., Electrochemicals Dept.
Harshaw Chemical Co.
Hommel, O., Co., Inc.
Innis, Speiden & Co.

Sodium Uranate
Ceramic Color & Chemical Mfg. Co.
Drakenfeld, B. F., & Co., Inc.
Harshaw Chemical Co.
Hommel, O., Co., Inc.

Soot Blowers
Frazier-Simplex, Inc.

Special Machines
Frazier-Simplex, Inc.

Spar
Ceramic Color & Chemical Mfg. Co.
Clinchfield Sand & Feldspar Corp.
Du Pont de Nemours, E. I., & Co., Inc., Electrochemicals Dept.
Eureka Flint & Spar Co.
Harshaw Chemical Co.
Hommel, O., Co., Inc.
Maxson, Elwyn L.
Vitro Mfg. Co.

Spray Booths
Ceramic Color & Chemical Mfg. Co.
Chicago Vitreous Enamel Product Co.
Hommel, O., Co., Inc.

Spraying Equipment
Ceramic Color & Chemical Mfg. Co.
Chicago Vitreous Enamel Product Co.
Hommel, O., Co., Inc.

Spurs
Potters Supply Co.

Stacks
Lancaster Iron Works, Inc.

Steel Plate Construction
Lancaster Iron Works, Inc.

Stilts
Chicago Vitreous Enamel Product Co.
Hommel, O., Co., Inc.
Industrial Ceramic Products, Inc.
Potters Supply Co.

Sulfur
Ceramic Color & Chemical Mfg. Co.
Hommel, O., Co., Inc.
Stauffer Chemical Co.

Sulfuric Acid
Harshaw Chemical Co.
Hommel, O., Co., Inc.
Pennsylvania Salt Mfg. Co.
Stauffer Chemical Co.

Talc (Lava)
Clinchfield Sand & Feldspar Corp.

Talcs
Ceramic Color & Chemical Mfg. Co.
Clinchfield Sand & Feldspar Corp.
Du Pont de Nemours, E. I., & Co., Inc., Electrochemicals Dept.
Hammill & Gillespie, Inc.
Harshaw Chemical Co.
Hommel, O., Co., Inc.
Innis, Speiden & Co.
International Pulp Company

Tank Pressure Controllers
Hays Corp.

Tanks
Frazier-Simplex, Inc.

Tank Blocks
Corhart Refractories Co.

Tanks (Pickle)
Hommel, O., Co., Inc.

Tanks for Raw Material Steel or Concrete
Lancaster Iron Works, Inc.

Tile (Floor)
Norton Co.

Tile (Muffle)
Carborundum Co.
Electro Refractories & Alloys Corp.
Norton Co.
Remmey, Richard C., Son Co.

Tile (Refractory)
Carborundum Co., (*Carbofrax*)
Electro Refractories & Alloys Corp.
Green, A. P., Fire Brick Co.
New Castle Refractories Co.
Norton Co
Remmey, Richard C., Son Co.

Tile (Wall)
Green, A. P., Fire Brick Co.

Tin Oxide
Ceramic Color & Chemical Mfg. Co.
Drakenfeld, B. F., & Co., Inc.
Du Pont de Nemours, E. I., & Co., Inc., Electrochemicals Dept.
Hommel, O., Co., Inc.
Metal & Thermit Corp.
Vitro Mfg. Co.

Titanium
Ceramic Color & Chemical Mfg. Co.
Drakenfeld, B. F., & Co., Inc.
Foote Mineral Co.
Harshaw Chemical Co.
Hommel, O., Co., Inc.
Orefraction, Inc.
Titanium Alloy & Mfg. Co.
Vitro Mfg. Co.

Titanium Oxide
Ceramic Color & Chemical Mfg. Co.
Drakenfeld, B. F., & Co., Inc.
Du Pont de Nemours, E. I., & Co., Inc., Electrochemicals Dept.
Foote Mineral Co.
Harshaw Chemical Co.
Hommel, O., Co., Inc.
Metal & Thermit Corp.
Titanium Alloy Mfg. Co.
Vitro Mfg. Co.

Trisodium Phosphate
Ceramic Color & Chemical Mfg. Co.
Harshaw Chemical Co.
Hommel, O., Co., Inc.

Trucks
Lancaster Iron Works, Inc.

Tubes (Insulating)
Carborundum Co.
McDanel Refractory Porcelain Co.
Norton Co.

Tubes (Pyrometer)
Carborundum Co.
Electro Refractories & Alloys Corp.
Leeds & Northrup Co.
McDanel Refractory Porcelain Co.
Montgomery Porcelain Products Co.
Norton Co.

Uranium Oxide
Ceramic Color & Chemical Mfg. Co.
Drakenfeld, B. F., & Co., Inc.
Ferro Enamel Corp.
Harshaw Chemical Co.
Hommel, O., Co., Inc.

Uranium Oxide (Yellow-Orange-Black)
Ceramic Color & Chemical Mfg. Co.
Drakenfeld, B. F., & Co., Inc.
Du Pont de Nemours, E. I., & Co., Inc., Electrochemicals Dept.
Ferro Enamel Corp.
Hommel, O., Co., Inc.
Vitro Mfg. Co.

Water Softening Plants
Frazier-Simplex, Inc.

Waxes (Beeswax, Carnauba, Refined yellow Beeswax)
Innis, Speiden & Co.

Wet Enamel
Ceramic Color & Chemical Mfg. Co.
Ferro Enamel Corp.
Hommel, O., Co., Inc.
Ingram-Richardson Mfg. Co. of Indiana, Inc.
Pemco Corp.
Titanium Alloy & Mfg. Co.
Vitro Mfg. Co.

Whiting
Ceramic Color & Chemical Mfg. Co.
Drakenfeld, B. F., & Co., Inc.
Du Pont de Nemours, E. I., & Co., Inc., Electrochemicals Dept.
Hammill & Gillespie, Inc.
Harshaw Chemical Co.
Hommel, O., Co., Inc.
Vitro Mfg. Co.

Winding Drums
Lancaster Iron Works, Inc.

Zinc Oxide
Ceramic Color & Chemical Mfg. Co.
Du Pont de Nemours, E. I., & Co., Inc., Electrochemicals Dept.
Harshaw Chemical Co.
Hommel, O., Co., Inc.
Vitro Mfg. Co.

Zircon
Ceramic Color & Chemical Mfg. Co.
Foote Mineral Co.
Hommel, O., Co., Inc.
Metal & Thermit Co.
Orefraction, Inc.

Zirconia
Ceramic Color & Chemical Mfg. Co.
Du Pont de Nemours, E. I., & Co., Inc., Electrochemicals Dept.
Foote Mineral Co.
Harshaw Chemical Co.
Hommel, O., Co., Inc.
Metal & Thermit Corp.
Orefraction, Inc.
Titanium Alloy & Mfg. Co.
Vitro Mfg. Co.

Zirconium Oxide
Ceramic Color & Chemical Mfg. Co.
Foote Mineral Co.
Hommel, O., Co., Inc.
Orefraction, Inc.
Titanium Alloy Mfg. Co.

Zircon Refractories
Remmey, Richard C., Son Co.

Zirconium Silicate
Orefraction, Inc.

Zirconium Silicate and Ultrox
Hommel, O., Co., Inc.
Metal & Thermit Corp.

Zirkite (Natural ZrO_3)
Foote Mineral Co.
Hommel, O., Co., Inc.

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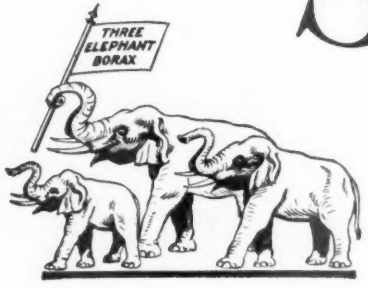

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